NATIONAL INTERAGENCY WORKSHOP ON WETLANDS: TECHNOLOGY ADVANCES FOR WETLANDS SCIENCE

3-7 APRIL 1995, NEW ORLEANS, LOUISIANA

- SPONSORED BY THE U.S. ARMY CORPS OF ENGINEERS
  WATERWAYS EXPERIMENT STATION
- IN COOPERATION WITH
  DEPARTMENT OF INTERIOR
  US FISH AND WILDLIFE SERVICE
  NATIONAL BIOLOGICAL SERVICE
  NATIONAL PARK SERVICE
  BUREAU OF RECLAMATION
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  BUREAU OF LAND MANAGEMENT
  US GEOLOGICAL SURVEY
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  US ENVIRONMENTAL PROTECTION AGENCY
  US TENNESSEE VALLEY AUTHORITY

MARY C. LANDIN, EDITOR

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PREFACE

Wetland research and applications, especially technology advances in wetlands, have progressed at a rapid rate over the past several years. The nearly 200 technical abstracts and summaries presented at this workshop and contained in this proceedings represent many of those latest advances. Acknowledging and practicing sound science and engineering aspects of wetlands has never been more critical, and should be used to make the critical decisions necessary regarding wetlands and natural resources at the federal, state, and local community level.

The national interagency workshop on wetlands was sponsored by the US Army Corps of Engineers, and conducted by the US Army Engineers Waterways Experiment Station. Mr. Richard E. Coleman and Dr. Mary C. Landin were workshop coordinators, and were assisted by Mr. Glenn Rhett, Mr. Harvey L. Jones, Ms. Linda E. Winfield, and other staff members in the Environmental Laboratory.

Federal agencies participating in and involved in helping make this workshop a success are:

DOI US Fish and Wildlife Service
DOI National Biological Service
DOI National Park Service
DOI Bureau of Reclamation
DOI Bureau of Mines
DOI Bureau of Land Management
DOI US Geological Survey
USDA Natural Resources Conservation Service
USDA Forest Service
DOT Federal Highway Administration
DOC NOAA National Marine Fisheries Service
DOE Department of Energy
US Environmental Protection Agency
US Tennessee Valley Authority
DOD US Army Corps of Engineers

This proceedings was rapidly compiled, with light editing, by Dr. Mary C. Landin from information recently provided by authors, in order to have it available for distribution during the workshop. Only 500 copies were initially printed. Any additional printings following this workshop will have a more thorough edit conducted prior to re-printing.

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PROGRAM AND SUMMARIES OF PRESENTATIONS:
NATIONAL INTERAGENCY WORKSHOP ON WETLANDS

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NATIONAL INTERAGENCY WORKSHOP ON WETLANDS

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	9:45 - 10:15				BREAK		
	10:15 - 12:00	CP2	ID2	WP2	RE3	RE4	SM2
	12:00 - 1:30 pm				LUNCH		
	1:30 - 3:15	CP3		WT1	RE5	RE6	SM3
	3:15 - 3:45				BREAK		
	3:45 - 5:30	CP4		MB1	RE7	RE8	SM4
	5:30				ADJOURN		

Thursday	Time	Audubon A	Audubon B	Audubon C	Audubon D	Audubon E	Cypress Room
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	12:00 - 1:30 pm				LUNCH		
	1:30 - 3:15	FA2	CW3	MB4	RE13	RE14	SM7
	3:15 - 3:45				BREAK		
	3:45 - 5:30		CW4	MB5	RE15	RE16	SM8
	5:30				ADJOURN		

CP - Critical Processes
ID - Identification and Delineation
WP - Watershed Planning
SM - Stewardship and Management
CW - Constructed Wetlands

WT - Wetland Training
MB - Mitigation and Mitigation Banking
RE - Restoration, Protection, and Creation
FA - Assessing Wetland Functions

FINAL AGENDA

NATIONAL INTERAGENCY WORKSHOP ON WETLANDS
New Orleans, Louisiana, 3-7 April 1995

Monday, 3 April 1995

1300-1850	Registration - Mezzanine
1800-2000	Ice Breaker (Cash Bar) - Tulane Room

Tuesday, 4 April 1995

0800-1730 Registration - Mezzanine

0800-0930 **Welcome and Plenary Session** - Salon A
Moderator, Dr. Russell F. Theriot, Director, Wetlands Research and Technology Center, US Army Engineer Waterways Experiment Station, Vicksburg, MS

Welcome: COL Kenneth H. Clow, Commander, US Army Engineer District, New Orleans

Speakers:

Dr. William Roper, Assistant Director, Research and Development (Civil Works), Headquarters, US Army Corps of Engineers

Mr. Robert Schroeder, Chief/Planning Division, US Army Engineer District, New Orleans

Mr. Michael Davis, Associate Direct for Natural Resources, White House Office on Environmental Policy

0930-1015 BREAK

1015-1200 **Wetlands Research Program Panel.** Dr. Theriot, Moderator

Mr. Richard Coleman
Mr. Jack E. Davis
Mr. Ellis J. Clairain Jr.
Dr. Mary C. Landin
Mr. Chester O. Martin
Ms. Elke Briuer

1200-1330 LUNCH (on your own)

1330-1515 Federal Panel II: Agency Initiatives. Dr. Billy M. Teels, Moderator, USDA Natural Resources Conservation Service, Washington, DC

Mr. Robert Belous, USDI National Park Service, New Orleans, LA
Mr. Paul A. Garrett, DOT Federal Highway Administration, Washington, DC
Dr. Eric Zobrist, USDI National Marine Fisheries Service, Silver Springs, MD
Mr. Gregory Peck, Environmental Protection Agency, Washington, DC
Mr. Porter B. Reed Jr., USDI Fish and Wildlife Service, St. Petersburg, FL

1515-1545 BREAK

1545-1730 **Federal Panel III.** Dr. Robert E. Stewart, Moderator, USDI National Biological Service, Lafayette, LA

Mr. Douglas Ryan, USDA Forest Service, Washington, DC
Dr. Les Behrends, Tennessee Valley Authority, Chattanooga, TN
Mr. Edward Beddow, USDI Bureau of Reclamation Service, Denver, CO
Dr. Virginia Carter, US Geological Survey, Reston, VA
Dr. Robert L. Kleinmann, USDI Bureau of Mines, Pittsburgh, PA

Wednesday, 5 April 1995

0800-1730 Registration - Mezzanine

0800-1730 **Concurrent Technical Sessions**

0945-1015 BREAK
1200-1330 LUNCH (on your own)
1515-1545 BREAK

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0800-1730 **Concurrent Technical Sessions**

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Mr. Ellis J. Clairain Jr.---Identification and Delineation

Mr. Jack E. Davis---Critical Processes
Mr. Chester O. Martin---Stewardship and Management
Dr. L. Jean O'Neil---Mitigation and Mitigation Banking
Ms. Laura Mazanti---Watershed Planning
Mr. John W. Bellinger---Wetland Education and Training
Mr. Tommy E. Myers---Constructed Wetlands
Mr. R. Daniel Smith---Assessing Wetland Functions

0945-1015 BREAK

1015-1200 **Interagency Panel: Technology for the 21st Century**

Dr. Russell F. Theriot
Mr. Paul A. Garrett
Mr. Gregory Peck
Dr. Robert E. Stewart
Dr. Billy M. Teels

1300 Optional Field Trips

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0820 RE1-2 **Creation of Forested Wetlands on Gravel Mine Sites: Construction and Implementation,** A. S. Garlo, W. J. Barry, and C. A. Wood
0840 RE1-3 **The Enhancement of Capillary Fringe Moisture Retention Through Soil Modifications in a Created Wetland,** I. Garskof, S. Bason, R. Day, and K. Goyne
0900 RE1-4 **Effects of Hydric vs. Loam Backfill on Survivorship and Plant Community Structure in a Mitigation Site in Central Connecticut,** D. A. Roberts, J. A. Weier, and S. Ladd
0920 RE1-5 **Considerations for Creation of a *Spartina* Salt Marsh in the Northeast,** M. W. Long

Session RE2: Title - Restoration, Protection, and Creation: Engineering And Geographic Information Systems, Session Chair, Dr. Mary C. Landin, US Army Engineer Waterways Experiment Station---Audubon E, 0800-0945 hours

0800 RE2-1 **Hydrological Restoration of Wetlands by Hydraulic Modifications,** C. C. Tai and C. Fong
0820 RE2-2 **ASTM Standard Guide for Wetlands Assessment, Design,**

		and Construction, J. S. Bays, K. Martin, and D. M. Gibb
0840	RE2-3	**Using Geographic Information Systems to Identify and Prioritize Potential Wetland Restoration Sites in Coastal North Carolina**, B. P. Bledsoe, J. E. Wuenscher, and L. A. Sutter
0900	RE2-4	**Shallow Water Terrace Construction Requirements**, W. R. Talbot
0920	RE2-5	**Expert System Programs for Geotechnical Factors in Wetland Engineering**, S. J. Spigolon

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0820	ID1-2	**Identifying and Delineating Arid Saline Wetlands: Factors to Consider**, J. W. Teaford and G. M. Honan
0840	ID1-3	**Vegetation of Plowed and Unplowed Playa Lake Wetlands in Southwest Kansas**, S. L. Wilson
0900	ID1-4	**Mississippi Pine Savannahs, Pine Flatwoods and Forested Bayheads: Wetland Delineation, Evaluation, and Mitigation Considerations**, J. W. Teaford, P. L. Lewis, and D. B. Johnson

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0820	CP1-2	**Bird Communities in Relation to the Floodplain Forest Zones along the Cache River, AR**, J. S. Wakeley and T. H. Roberts
0840	CP1-3	**Designing Wetlands for Species Richness: Macroinvertebrate Requirements**, D. H. Jones, R. B. Atkinson, and J. Cairns Jr.
0900	CP1-4	**The Hydrology of Longleaf Pine Savannah Wetlands in Louisiana**, C. P. Schmidt and S. P. Faulkner
0920	CP1-5	**Small Mammals, Reptiles, and Amphibians in Bottomland Hardwoods of the Cache River, Arkansas**, L. J. O'Neil and D. H. Wilber

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0820	SM1-2	**Resource Categorization of Nebraska's Eastern Saline Wetlands**, M. C. Gilbert and R. Stutheit
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0820 WP1-2 **Framework for Wetland Systems Management**, A. G. Warne and L. Smith

0840 WP1-3 **Wetlands Restoration As an Element of a Multi-Objective Watershed Restoration Project**, S. Hughes and V. Ross

0900 WP1-4 **Watershed-Wide Planning for Stormwater, Parks, and Wetlands**, M. Ray

0900 WP1-5 **Water Supply Potential and Environmental Benefits of an Everglades Buffer**, W. Dunn, S. Gong, and T. Strowd

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1035 RE3-2 **Restoration of Lost Lake: Recovery of an Impacted Carolina Bay**, L. D. Wike, H. E. Mackey Jr., V. A. Rogers, and J. B. Gladden

1055 RE3-3 **Amphibian and Reptile Recolonization of Lost Lake, a Restored Carolina Bay**, J. G. Hanlin, L. D. Wike, B. M. Dietsch, and J. P. McLendon

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1035 RE4-2 **Designing a Multi-Functional Freshwater Wetland System at the Ballona Wetlands, Los Angeles, CA**, J.

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1055 RE4-3 **Using Geomorphic Relationships in Designing Tidal Slough Channels**, R. N. Coats, C. K. Cuffe, P. B. Williams

1115 RE4-4 **A Retrospective on a "Win-Win" Wetlands Mitigation Project: Creation of the Warm Springs Marsh in San Francisco Bay**, R. C. Douglass

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1055 ID2-3 **A Common Error in Assessing the Hydrophytic Vegetation for Wetland Identification**, F. C. Weinmann and K. Kunz

1115 ID2-4 **Washington Regional Guidance on the 1987 Wetland Delineation Manual**, D. J. Knaub and F. C. Weinmann

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1350 RE5-2 **Bottomland Restoration in the Southeastern Coastal Plain**, K. W. McLeod, M. R. Reed, V. H. Parrish, and T. G. Ciravolo

1410 RE5-3 **Restoration of a Forested Wetland in a Thermally Impacted Stream Corridor**, E. A. Nelson, W. H. McKee Jr., and C. J. Dulohery

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1350 RE6-2 **The Coastal Dune Wetlands Creation Program at Vandenberg AFB: Construction and Hydrologic Monitoring**, O. J. Kensok and P. Peyton

1410 RE6-3 **Wildlife Monitoring of Created Dune Swale Wetlands on the San Antonio Terrace, Vandenberg Air Force**

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1410 CP3-3 **Vegetative Study of Selected Wetland Sites in the Lower Colombia River**, M. R. Smith and J. Goudzwaard

1430 CP3-4 **Swamp Forest Vegetation and Hydrology Along Microtopographic Gradients**, B. Bledsoe and T. Shear

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1625	CP4-3	Flood Mitigation Impacts of a Fringe Wetland, K. Lansey
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1625	SM4-3	**Cumulative Impact Analysis of Wetlands Using Hydrologic Indices,** J. M. Nestler and K. S. Long
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1605	MB1-2	**A Strategy for Monitoring the Success of Wetland Mitigation: Portland District's Experience,** B. W. Lightcap
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1645	MB1-4	**Monitoring of a Wetland Mitigation Site in the Sacramento River Delta, California,** M. L. Stevens and E. Rejmankova
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6 April 1995

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0820	RE9-2	**Evaluation of Weaver Bottoms Restoration Project on the Upper Mississippi River,** M. M. Davis, E. Nelson,

		D. Anderson, and J. Hendrickson
0840	RE9-3	Creating Wetlands to Enhance a Golf Course: Sowing Seeds of Success, R. Suttle and S. Bedross
0900	RE9-4	Avian Utilization of Restored and Created Wetlands in Indiana, P. J. DuBowy, R. Hartman, and Y. A. Mulyani
0920	RE9-5	Wetland Construction and Enhancement at the Gerald Gentleman Station Rail Spur Mitigation Site, Progress of the First Year, M. P. Gutzmer and D. P. Overhue

Session RE10: Title - Restoration, Protection, and Creation: General Wetland Creation and Restoration, Session Chair, Ms. Suzanne Hawes, US Army Engineer District, New Orleans, LA---Audubon E, 0800-0930 hours

0800	RE10-1	Beneficial Use of Dredged Material from the Delaware River Main Channel Deepening Project to Create, Restore, and Protect Wetlands in the Delaware Bay, J. T. Brady
0820	RE10-2	Restoration of Saginaw Bay Coastal Wetlands in Michigan, T. M. Burton and H. H. Prince
0840	RE10-3	Wetland Restoration and Management in the City of West Palm Beach, FL, Water Resource Program, R. W. Ogburn III, W. E. Olson, and D. R. Hubbs
0900	RE10-4	Soil as a Biological Interface in Wetland Construction, M. N. Gilbert

Session CW1: Title - Constructed Wetlands: Water and Wastewater Treatment, Session Chair, Mr. Tommy E. Myers, US Army Engineer Waterways Experiment Station---Audubon B, 0800-0930 hours

0800	CW1-1	Constructed Wetlands for Storm Water Management on Army Installations, R. Scholze
0820	CW1-2	Biodenitrification of Fresh Water by Constructed Wetlands, S. R. Liming
0840	CW1-3	Sugarcane Factory Wastewater Treatment in a Diked Wetland, D. D. Adrian and Y. Zhang

Session SM5: Title - Stewardship and Management: Fish and Wildlife Habitat Management 1, Session Chair, Mr. Chester O. Martin, US Army Engineer Waterways Experiment Station---Cypress, 0800-0930 hours

0800	SM5-1	A Synopsis of Stewardship and Management Demonstration Studies for the Corps of Engineers Wetlands Research Program, C.O. Martin and J. W. Teaford
0820	SM5-2	Early Life History of Northern Pike in Artificial Wetlands of Conesus Lake, New York, J. V. Morrow, K. J. Killgore, and G. L. Miller
0840	SM5-3	Riverine-Wetland Connections and Larval Fish Dynamics of Bottomland Hardwood Systems, J. J.

Hoover and K. J. Kilgore

0900 SM5-4 **Management of Shallow Impoundments to Provide Emergent and Submergent Vegetation for Waterfowl,** L. G. Polasek, M. W. Weller, and K. C. Jensen

0920 SM5-5 **Wildlife Habitat Functions in Created Wetlands,** K. C. Jensen, G. L. Phillips, and K. Luttschwager

Session MB2: Title - Mitigation and Mitigation Banking: Strategies in Mitigation 1, Session Chair, Ms. Lynn R. Martin, Institute of Water Resources---Audubon C, 0800-0930 hours

0800 MB2-1 **A Mitigation Banking Proposal for the Playa Vista Project, Los Angeles, California,** S. Lockhart, D. Vena, and J. Stensby

0820 MB2-2 **Florida's First Fully-Entrepreneurial Wetland Mitigation Bank,** R. Robinson, S. Jones, and T. Gipe

0840 MB2-3 **Intergration of Wetland Research and Monitoring into the Wetland Mitigation Design Process: A Case Study,** A. L. Kline

0900 MB2-4 **An Ecosystem Approach to Compensatory Wetland Mitigation,** R. Harmon and D. Huggett

0920 MB2-5 **Structure and Successes of the Ohio Wetlands Foundation's Consolidated Mitigation System,** C. E. Siegley and S. C. D. Ahern

Session CP5: Title - Critical Processes: Wetland Processes, Soils Development, Chemistry, and Erosion, Session Chair, Mr. Jack E. Davis, US Engineer Waterways Experiment Station---Audubon A, 0800-0930 hours

0800 CP5-1 **Monitoring the Physical Environment of Low-Salinity Rooted and Buoyant Marshes in Coastal Louisiana,** C. M. Swarzenski, T. W. Doyle, and T. G. Hargis

0820 CP5-2 **Evaluation of Four Chemical Extractants for Metal Determination in Wetland Soils,** K. R. Sistani, D. A. Mays, R. W. Taylor, and C. Buford

0840 CP5-3 **The Use of Soil Morphological Features to Predict High Ground Water Tables in Problematic Soils of Southern New England,** B. C. Lesinski, W. R. Wright, and T. E. Sokoloski

0900 CP5-4 **Redox Potentials Across a Transect from Hydric to Non-Hydric Soils,** K. E. Fessel and R. P. Gambrell

0920 CP5-5 **The WESWAVES Project: Wave Action and the Erodibility of Salt Marsh Soils,** G. P. Kemp, J. N. Suhayda, J. Day Jr., and R. M. J. Boumans

Session RE11: Title - Restoration, Protection, and Creation: General Freshwater Wetland Restoration and Creation, Session Chair, Ms. Linda E. Winfield, US Army Engineer Waterways Experiment Station---Audubon D, 1015-1200 hours

1015 RE11-1 **Hydrologic Design and Restoration Plan for the**

Three Forks Marsh Conservation Area, A. K. Borah, S. J. Miller, D. V. Rao, and C. C. Tai

1035 RE11-2 **Creating Wetlands from Farm Land in Central Florida**, J. E. Marburger and W. F. Godwin

1055 RE11-3 **Wetland Restoration to Benefit Endangered Fish Habitat in the Upper Colorado River Basin**, G. R. Smith

1115 RE11-4 **Mitigation in Detention Basins in Harris County, Texas**, S. I. Silva, P. A. Matthews, R. C. Esenwein, and S. Fitzgerald

1135 RE11-5 **Physical Effects of Navigation on Wetlands**, S. T. Maynord and J. E. Davis

Session RE12: Title - Restoration, Protection, and Creation: Wetland Restoration In Coastal Louisiana and Texas, Session Chair, Dr. Conrad J. Kirby, US Army Engineer Waterways Experiment Station---Audubon E, 1015-1200 hours

1015 RE12-1 **Vegetative Responses to Implementation of Cameron-Creole in Southwestern Louisiana, an Ecosystem-Based Watershed Project**, M. D. Floyd

1035 RE12-2 **Status Report on the Crevasse Program at Delta National Wildlife Refuge, LA**, J. O. Harris

1055 RE12-3 **Sediment and Vegetation Characteristics of Similar-Aged Created and Natural Freshwater Wetlands in the Louisiana Atchafalaya Delta**, S. Faulkner and J. Visser

1115 RE12-4 **Fishery Utilization of Established/Restored Wetlands**, W. N. Brostoff, D. N. Allen, M. H. Posey, C. M. Powell, T. D. Alphin, T. J. Minello, C. A. Simenstad, R. M. Thom, M. S. Fonseca, G. W. Thayer, D. L. Meyer, and V. G. Thayer

1135 RE12-5 **Performance of Erosion Control Measures for Coastal Wetlands Restoration and Creation Projects**, J. E. Davis and J. W. McCormick

Session CW2: Title - Constructed Wetlands: Nitrogen and Phosphorus Removal Efficiencies, Session Chair, Mr. Tommy E. Myers, US Army Engineer Waterways Experiment Station---Audubon B, 1015-1200 hours

1015 CW2-1 **The Response of a Freshwater Wetland to Long-Term, Low Level Nutrient Loads**, M. Z. Moustafa, T. D. Fontaine, and M. J. Chimney

1035 CW1-2 **Constructed Wetlands for Livestock Waste Management**, P. J. DuBowy and R. P. Reaves

1055 CW2-3 **Constructed Wetlands For Sediment Control and Non-Point Source Pollution Abatement at US Army Corps of Engineers Projects, Ray Roberts Lake, Texas, and Bowman-Haley Reservoir, North Dakota**, C. W. Downer and T. E. Myers

1105 CW2-4 **A Proposed Amendment to the Exemptions of Section 404 of the Clean Water Act Reauthorization,**

S. Whitesell, S. deMonsabert, and D. Branson

Session SM6: Title - Stewardship and Management: Fish and Wildlife Habitat Management 2, Session Chair, Mr. Chester O. Martin, US Army Engineer Waterways Experiment Station---Cypress, 1015-1200 hours

1015	SM6-1	**Conserving Biological Diversity: Applications to Management of Freshwater Wetlands**, J. H. Giudice, J. T. Ratti, and C. O. Martin
1035	SM6-2	**Wildlife and Vegetation Monitoring of Constructed Wetlands at Ray Roberts Lake, Denton, Texas**, M. J. Flores and M. Hackett
1055	SM6-3	**Wetland Restoration and Management at the Riverlands Environmental Demonstration Area, Pool 26 - Upper Mississippi River System**, P. S. McGinnis, J. D. Cannon, C. H. Theiling, and J. K. Tucker
1115	SM6-4	**Management for Biodiversity in Riparian Ecosystems on Corps of Engineers Lands**, R. A. Fischer and C. O. Martin

Session FA1: Title - Assessing Wetland Functions: Hydrogeomorphic Approaches Perspective, Session Chair, Mr. R. Daniel Smith, US Army Engineer Waterways Experiment Station---Audubon A, 1015-1200 hours

1015	FA1-1	**A Comparison of Current Wetland Assessment Methods**, R. P. Novitzki
1035	FA1-2	**A Procedure for Assessing Wetland Functions Based on Functional Classification and Reference Wetlands**, R. D. Smith
1055	FA1-3	**The Hydrogeomorphic Approach as a Basis for Procedures of Functional Analysis of European Wetland Ecosystems**, E. Maltby, D. V. Hogan, and R. J. McInnes
1115	FA1-4	**New Procedures of Functional Analysis for European Wetland Ecosystems**, R. J. McInnes and E. Maltby
1135	FA1-5	**A Method for Assessing Hydrologic Alteration Within Ecosystems**, B. Richter, J. V. Baumgartner, J. Powell, and D. P. Braun

Session MB3: Title - Mitigation and Mitigation Banking: Strategies in Mitigation 2, Session chair, Ms. Lynn R. Martin, Institute for Water Resources---Audubon C, 1015-1200 hours

1015	MB3-1	**Expediting Water Projects: Benefits Assessment and Wetland Mitigation Banking**, W. Dunn, R. Mishaga, and J. Bays
1035	MB3-2	**Minnesota Wetland Conservation Act: Wetland Banking System**, J. Jaschke
1055	MB3-3	**Wetland Mitigation Banking: Solutions Through Consensus Building**, D. C. Hayes, R. C. Sundell, P. L. Wilkey, and K. A. Bailey
1115	MB3-4	**Wetland Mitigation at Jordanelle Wetlands and the**

		Seedskadee National Wildlife Refuge, S. Lloyd
1135	MB3-5	Fee-Based Compensatory Mitigation: Potential Roles of and Benefits for Conservation Agencies and Organizations, L. R. Martin and A. Doll

Session RE13: Title - Restoration, Protection, and Creation: Alaska and Pacific Northwest Restoration Projects, Session Chair, Mr. Lloyd H. Fanter, US Army Engineer District, Alaska---Audubon D, 1330-1515 hours

1330	RE13-1	An Evaluation of the Wetland Monitoring Program of the Washington State Department of Transportation, M. S. Savage
1350	RE13-2	Partnerships in Management by Experimentation for Gravel Pad Rehabilitation on Alaska's North Slope, L. H. Fanter and C. J. Herlugson
1410	RE13-3	Evaluation of Liquid Calcium (LCA-II) in Reducing Salinity for Arctic Tundra Rehabilitation, B. A. Reiley, J. D. McKendrick, and S. C. Lombard
1430	RE13-4	Long-Term Arctic Wetland Rehabilitation Research, C. J. Herlugson, J. D. McKendrick, and L. H. Fanter

Session RE14: Title - Restoration, Protection, and Creation: Beneficial Uses of Dredged Material, Session Chair, Dr. Mary C. Landin, US Army Engineer Waterways Experiment Station---Audubon E, 1330-1515 hours

1330	RE14-1	Phosphorus Characteristics of Created Dredged Material Marshes as Compared to Similarly Aged Natural Marshes, M. Poach and S. Faulkner
1350	RE14-2	Construction of a Demonstration Marsh Using Large Scale Cutter Head Dredging Equipment in Galveston Bay, Texas, K. P. Kindle
1410	RE14-3	Construction of a Marsh in the LaBranche Ponds of Louisiana, S. R. Hawes
1430	RE14-4	Innovative Alternative for Wetland Restoration: Transport and Distribution of Dredged Material by Large Hovercraft, T. J. Olin, M. R. Palermo, and A. C. Gibson
1450	RE14-5	Restoration of Forested Hardwood Wetlands Following Dredge Mining for Mineral Sands on Relict Beach in Northeast Florida, C. L. Saunders III

Session SM7: Title - Stewardship and Management: Other Management Technologies 1, Session Chair, Ms. Mary J. Flores, US Army Engineer District, Fort Worth, TX---Cypress, 1330-1515 hours

1330	SM7-1	Development of a Regional Wetland Preservation Plan for Vernal Pools in the Santa Rosa Plain, Sonoma County, California, L. P. Hosley and N. F. McCarten
1350	SM7-2	Resource Management and Planning for California's Central Valley Grassland/Vernal Pool Rangelands,

P. W. Sugnet

1410 SM7-3 **Evaluation of Mechanical and Chemical Methods for Control of Melaleuca** (Melaleuca quinquenervia) **in Southern Florida, USA**, A. F. Cofrancesco, J. W. Wooten, and H. L. Jones

1430 SM7-4 **Selective Control of Purple Loosestrife with Triclopyr**, L. S. Nelson, K. D. Getsinger, and J. E. Freedman

1450 SM7-5 **Incorporating Ecological Mosquito Control Into Managed Wetlands**, M. Ray and J. Lang

Session CW3: Title - Constructed Wetlands: Mining operations, Session Chair, Mr. Tommy E. Myers, US Army Engineer Waterways Experiment Station---Audubon B, 1330-1515 hours

1330 CW3-1 **Overview of Research at the Tennessee Valley Authority Constructed Wetland Research Facility**, F. J. Sikora and L. L. Behrends

1350 CW3-2 **Wetland Treatment of Mine Drainage**, P. Eger, J. Wagner, and G. Melchert

1410 CW3-3 **Sediment Accumulation Rates in TVA Constructed Acid Drainage Treatment Wetlands and the Implication on System Longevity**, J. Fry and H. N. Taylor

1430 CW3-4 **Creating Wetlands on Land Disturbed by Iron Mining**, G. Melchert, P. Eger, and S. Huerd

Session FA2: Title - Assessing Wetland Functions: Regional Approaches, Session Chair, Mr. R. Daniel Smith, US Army Engineer Waterways Experiment Station---Audubon A, 1330-1515 hours

1330 FA2-1 **A GIS-Based Landscape Scale Wetland Functional Assessment Procedure**, J. E. Wuenscher and L. A. Sutter

1350 FA2-2 **Wetland Function and Values: A Descriptive Approach**, T. A. Flieger and R. DeSanto

1410 FA2-3 **Rapid Assessment of Vernal Pool Floristics**, K. D. Whitney

1430 FA2-4 **The Wisconsin DNR Rapid Assessment Methodology: A Simple Qualitative Approach for Assessing Wetland Functional Values**, D. R. Siebert

Session MB4: Title - Mitigation Banking: Legal and Regulatory, Session Chair, Dr. Robert W. Brumbaugh, Institute for Water Resources--- Audubon C, 1545-1730 hours

1545 MB4-1 **An Overview of Legal and Regulatory issues in Wetland Mitigation Banking**, J. Ballweber

1605 MB4-2 **Wetland Creation and Mitigation Banking: An Industry Viewpoint**, A. J. Regis and W. D. Shalter

1625 MB4-3 **An Overview of Wetland Mitigation Banking: National Wetland Mitigation Study Findings and Ongoing Studies**, R. W. Brumbaugh

1645 MB4-4 **Commercial Credit Ventures: A Review of Recent**

Experiences, L. Shabman and P. Scodari

1705 MB4-5 **Statements on the Proposed Federal Interagency Guidance on Mitigation Banking**, J. J. Metz and R. W. Brumbaugh

Session RE15: Title - Restoration, Protection, and Creation: Chesapeake Bay Wetland Restoration, Session Chair, Ms. Trudy Olin, US Army Engineer Waterways Experiment Station---Audubon D, 1545-1730 hours

1545 RE15-1 **Hart-Miller and Poplar Islands: Restoration of Lost Fish and Wildlife Habitats in Chesapeake Bay, MD**, M. C. Landin, B. Walls, J. McKee, J. Griff, S. Brown, D. Bibbo, M. Hart, and J. Gill

1605 RE15-2 **Eastern Neck National Wildlife Refuge Salt Marsh: Innovative Structures and Bioengineering**, R. N. Blama, M. C. Landin, S. T. Maynord, and J. Gill

1625 RE15-3 **Kenilworth Marsh: A Classic Wetland Restoration Success Story in the Nation's Capitol**, S. D. Garbarino, R. N. Blama, M. C. Landin, R. S. Hammerschlag, and S. W. Syphax

1645 RE15-4 **Shoreline Stabilization and Restoration at Barren Island and Historic Smith Island, Chesapeake Bay: Innovative Geotextile Tube Technology**, R. N. Blama, S. D. Garbarino, J. Gill, and M. C. Landin

1505 RE15-5 **Survival and Growth of Nursery Stock Woody Plants in Created Forested Wetlands in Central Maryland**, M. C. Perry, A. S. Deller, and S. B. Pugh

Session RE16: Title - Restoration, Protection, and Creation: General Restoration and Creation Theory, Session Chair, Dr. Lawson M. Smith, US Army Engineer Waterways Experiment Station---Audubon E, 1545-1730 hours

1545 RE16-1 **Development of Monitoring Programs for the Purpose of Evaluating Natural and Modified Wetland Systems**, N. F. McCarten

1605 RE16-2 **Hydrological Information, Wetland Site Selection, and Wetland Design**, M. V. Miller, J. Miner, and N. Rodick

1625 RE16-3 **Design Criteria for Wetland Restoration and Establishment**, L. M. Smith

1645 RE16-4 **Wetland Restoration and Creation Handbook**, R. E. Holman and W. S. Childres

1705 RE16-5 **Performance Standards for Coastal Wetland Restoration**, R. F. Ambrose

Session SM8: Title - Stewardship and Management: Other Management Technologies 2, Session Chair, Ms. Mary F. Flores, US Army Engineer District, Fort Worth, TX---Cypress, 1545-1730 hours

1545 SM8-1 **Effects of Forest Management on Wetland Functions:**

Results from the First Five Years of the Forest Industry's Wetland Research Program, J. P. Shepard

1605 SM8-2 **Bottomland Hardwood Ecosystem Management Project,** J. A. Stanturf, M. K. Burke, and C. E. Meier

1625 SM8-3 **Plants for Coastal Wetlands of the North Central Gulf of Mexico,** G. L. Fine

1645 SM8-4 **Collecting and Commercializing Native Wetland Species for Seed Production,** S. J. Wright

1705 SM8-5 **Private Property, Takings and Wetlands Management,** L. Shabman and D. White

Session CW4: Title - Constructed Wetlands: Vegetation Management, Session Chair - Mr. Tommy E. Myers, US Army Engineer Waterways Experiment Station---Audubon B, 1545-1730 hours

1545 CW4-1 **Importance of Open Water Areas in Constructed Wetlands at San Jacinto, CA,** L. E. Hamilton

1605 CW4-2 **Seedbank Composition of a Constructed Wetland,** G. R. Wein and B. S. Collins

1625 CW4-3 **Assessment of Plant Performance in Constructed Wetland Modules: A New Experimental Approach,** S. Garton, C. T. Pounders, and T. G. Jensen

Session MB5: Title - Mitigation and Mitigation Banking: Functions and Credits, Session Chair, Dr. L. Jean O'Neil, US Army Engineer Waterways Experiment Station---Audubon C, 1545-1730 hours

1330 MB5-1 **Wetland Assessment Methods: Applications to Mitigation Banking,** L. J. O'Neil and J. J. Metz

1350 MB5-2 **An Alternative Methodology for Determining Wetland Functional Values,** F. G. Stanholtzer

1410 MB5-3 **Application of a Combined Approach of the Hydrogeomorphic Method and Landscape Ecosystem Classification on the Northeast Florida Mitigation Bank,** S. M. Jones, W. Nutter, and J. Gaskin

1430 MB5-4 **The Cocohatchee Strand Restoration Program: A Unique Project-Specific Mitigation Bank,** C. Carithers

1450 MB5-5 **A Quantified Method for Calculating Wetland Mitigation Bank Credits Using WET 2.0 Version,** M. Oliver and J. Koros

FEDERAL PANEL I:
US ARMY CORPS OF ENGINEERS WETLANDS RESEARCH PROGRAM PANEL

THE CORPS' WETLANDS RESEARCH PROGRAM

Russell F. Theriot, PhD
Environmental Laboratory
US Army Engineer Waterways Experiment Station
Vicksburg, MS 39180

The US Army Corps of Engineers (Corps) has broad responsibilities associated with its regulatory programs as they relate to the protection of our nation's wetland resources. Accomplishment of this mission requires scientific investigation into wetlands ecology, science and engineering technologies. The U. S. Army Engineer Waterways Experiment Station (WES) has conducted wetlands-related research for more than twenty years. Early products included incorporating state-of-the-science information into descriptive analyses of wetlands in various geographic regions of the United States. This was followed by Corps' guidance documents that provided techniques for applying criteria to establish and defend findings on wetlands delineations and wetlands evaluations. While these guidance documents began to be field tested and used by the Corps field elements and others, the research emphasis began to shift from wetlands delineation and evaluation to wetland restoration and management.

In 1990, WES began a major new research initiative to: (1) develop better engineering and design criteria for creating, restoring, enhancing, or protecting wetlands for specific functions. A need also existed to continue to improve our understanding of wetlands processes and ecosystems (Cache River Study, etc.).

Also, based on the field use of the Corps Delineation Manual and Wetland Evaluation Techniques (WET), WES conducted R&D to improve the technical guidance by identifying more specific wetland type field indicators for wetland boundaries and by developing the new hydrogeomorphic classification system for identifying specific wetland functions. This new system can be used to relate existing or proposed wetlands to reference wetlands at a regional level by comparison to the dynamics and landscape position of the wetlands.

To accomplish this new initiative the Wetlands Research Program was divided into six task areas: (1) Interagency coordination, (2) Technology and information transfer, (3) Wetland processes, (4) Wetlands characterization, (5) Restoration, Protection and creation

of wetlands, and (6) Stewardship and management of wetlands. The following presentations will briefly describe each task area and the work that was accomplished in each.

TASK AREA I - INTERAGENCY COORDINATION

Richard E. Coleman, Task Manager
Environmental Laboratory
US Army Engineer Waterways Experiment Station
Vicksburg, MS 39180

A major objective of The Wetlands Research Program (WRP) was to coordinate with federal and state resource and regulatory agencies, private conservation groups, commercial and private interests traditionally associated with U.S. Army Corps of Engineer (USACE) projects, and USACE field offices and laboratories. This coordination was essential in order to ensure that research was not duplicated by two or more agencies (and money wasted), and to ensure the best science was achieved in the program. Coordination activities included actual collaborative work by scientists in collecting and analyzing field data and in developing interagency documents on wetlands. The scope of these activities extended from individual scientists at project sites to the national level, wherein the Headquarters USACE staff and WRP program management worked to achieve effective coordination with other Federal agencies and national target groups.

At the national level the WRP provided leadership in hosting interagency meetings to assess status and formulate future goals for Federal cooperation. One of these, the Federal Interagency Coordination Committee on Wetlands Research and Development, was organized and conducted annual meetings in Washington, D.C. throughout the WRP. Another committee, the Forested Wetlands Research and Development Coordination Committee, formed working groups and generated a multi-year research proposal for cooperative research in forested wetlands. At the urging of the Corps, Tennessee Valley Authority and U.S. Bureau of Reclamation, a Wetlands Research Session was established under the auspices of the Interagency Research Coordination Conference, a Congressionally mandated multi-agency and private industry group which meets semi-annually to exchange information and coordinate research activities. The WRP also coordinated with the National Resources Council and involved member organizations in regional and site-specific projects, such as the Lindon Q. Skidmore Wetlands Management Area, a cooperative project between the USACE and Ducks Unlimited. WRP scientists also participated in national, regional or local meetings of the American Society of Civil Engineers (ASCE), the Associated General Contractors of America (AGC),

American Public Works Association (APWA), and other groups and organizations that routinely work with the Corps in accomplishing missions. The WRP co-sponsored a national workshop with the Association of State Wetland Managers, which provided a forum for state and local government input and participation in projects and demonstrations.

In 1991 the WRP compiled a report "National Summary of On-going Wetlands Research by Federal Agencies" to facilitate coordination by the Federal community. In 1992, at the request of the Bush Administration's Wetlands Subcommittee of the Committee on Earth and Environmental Sciences, and with the cooperation of other Federal agencies, the WRP completed a comprehensive National Inventory and Data Base of Wetlands Research by Federal Agencies.

Through these and other efforts the U.S. Army Corps of Engineers has established and continues to emphasize the importance of coordination and cooperation with others in executing its' national wetlands research program. In this regard the Corps will continue to support the Army and the Nation with the best engineering and science for water resource missions.

TASK AREA II - TECHNOLOGY TRANSFER

Ms. Elke Briuer, Task Manager
Information Technology Laboratory
US Army Engineer Waterways Experiment Station
Vicksburg, MS 39180

From the beginning of the Wetlands Research Program in 1991, the U.S. Army Corps of Engineers focused on the need for technology transfer of research results to many and diverse audiences. Research included studies on wetland processes, delineation, evaluation, restoration, and creation, as well as monitoring and managing wetlands. The work included field and laboratory work, PC-based modeling, literature reviews, and development of guidance.

More than 60 scientists and engineers at the U.S. Army Engineer Waterways Experiment Station worked on the program, in addition to those contracted from universities, government agencies, and private organizations. It was, therefore, important to plan a unified approach to accomplish the technology transfer mission, which mandated transmittal of emerging research results and technologies to the appropriate users, by the most expedient method, in the best suited format. How this mission was to be accomplished was published in an Administrative Management Plan,

outlining a standardized approach--a strategy so to speak--to administrative and management functions that dealt with technology transfer. This plan provided samples and guidelines to principal investigators for producing reports, technical notes, bulletin articles, and other traditional technology transfer materials. In addition, new methods and products--such as computer-based products or ventures with industry partners--were recommended. Products for the WRP have been developed in the following formats:

Technical Reports are issued in a series, printed on recycled paper. A unifying appearance for all products is the recycled ivory paper, blue soy-bean based ink, and a wetland graphic design. Distribution is to Corps districts and divisions and WRP partners in other federal agencies. Technical reports are available through NTIS and WES interlibrary loan service to the general public.

The **WRP Notebook** uses the same distinguishing features as the technical reports and is a collection of technical notes covering eight general areas of wetlands technology and a subject index in loose-leaf format. Distribution is to Corps divisions, districts, and field offices and to our research partners. Orders for individual copies of technical notes are accepted from the general public.

The **WRP Bulletin** is published quarterly and is available free of charge upon request. The primary function is to publish research results, but training opportunities and program news are included. Currently, the bulletin has more than 4,500 subscribers. Since the October 1994 issue, the bulletin is available electronically on the World Wide Web, where the WRP has a home page under the Wetlands Research and Technology Center at the Waterways Experiment Station.

The **overview video**, with the title the U.S. Army Corps of Engineers Wetlands Research Program, was distributed in January 1993, outlining program objectives. A **restoration and creation video** was released during 1994. This video details restoration field techniques with information about engineering, planning, soils, bioengineering, and forested wetland and salt marsh case studies. Distribution was to Corps offices and to program research partners. Both videos are available through interlibrary loan. The WRP also uses the **video Fabulous Wetlands** in Corps education outreach programs. The video, a joint EPA and Washington State production, is used by permission from the Washington State Department of Ecology.

Miscellaneous. A WRP brochure, the color pamphlet Recognizing Wetlands, a presentation wetland folder, as well as the USGS wetland education posters, Wetlands: Water, Wildlife, Plants & People, continue to be in demand for use in public outreach, with exhibits, and for general Corps use. The USGS posters have education modules for grade and middle school and were a joint

agencies project, including the Corps WRP and the U.S. Fish and Wildlife Service which was the lead agency for poster contents. The WRP created, reproducible booklet The Young Scientist's Introduction to Wetlands is popular at schools throughout the United States and is also for sale by the Superintendent of Government Documents. Corps districts have used the booklet in "train the teacher" programs in several States and also in EcoFairs, a Corps program involving school science team competitions.

WRP travelling **exhibits** reached more than 160,000 viewers during the past three years, supporting the mission of Corps divisions and districts, and were also used by conservation groups and state agencies.

As the program drew to an end, it was important to plan for dissemination of information about the results of all of the WRP studies. A **compact disk** has been distributed that lists research results by study site, keyed to a U.S. map, with photos and some video footage included. A computer floppy disk version is also available, without the photos and videos. The CD-ROM is available through WES interlibrary loan service.

One project involving numerous studies at the **Cache River, Arkansas,** has been highlighted in a 55 minute video, to be distributed to public television stations later this year. In addition to this video report to the public, a special issue of the Society of Wetland Scientists Journal will feature research studies from the Cache, transferring the results to the scientific community. WRP studies have resulted in graduate theses and disserations, and peer-reviewed articles; this type of technology transfer is expected to continue for several years.

With an emphasis on quality, demand for WRP products has increased exponentially since program inception. By assuring the widest information dissemination, Wetland Research Program results promise to impact on how wetlands will be perceived and managed in the future. In addition, public access to WRP products is available nationwide, since the WRP technology transfer program supports Corps Districts and Divisions in their public education outreach efforts.

TASK AREA III - WETLAND CRITICAL PROCESSES

Jack E. Davis, PE, Task Manager
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station
Vicksburg, MS 39180

The Critical Processes Task Area was developed to investigate the interactions between physical, chemical and biological processes and the relationships between these processes and wetland functions. The goal was to increase our understanding of wetland processes and functions to the extent that we could better evaluate them and predict how they might be affected by proposed wetland changes. Four work units were developed under the task area to specifically investigate wetland processes, namely hydraulic and hydrologic processes, sediment processes, water quality processes, and soil processes. A fifth work unit was established to conduct field investigations of wetland functions for specific wetland types.

The field investigations work unit was a focal point for activities within the task area. The field study continued our research into the functions of bottomland hardwoods (BLH) found along the Cache River in eastern Arkansas. Researchers involved in the field study were able to increase our understanding of BLH functions and their outstanding set of field data was used by the other task area work units to verify numerical simulation models developed during the program. The data collected during the field study included the diversity and abundance of wildlife, amphibians, birds, and fishes, the distribution of vegetation, meteorology, river stages and discharges, groundwater, suspended sediment concentrations, sedimentation rates, water chemistry, and carbon dynamics. The results of the field study are documented in several WES technical reports. A condensed version of the study results are also scheduled for publication in a 1996 special issue of Wetlands.

While the Cache River field investigation was the most intensive, it was not the only field study conducted under this task area. Other investigations included:

a. A study of waves and wave-induced erosion in small wetland ponds (Coastal, LA).

b. A lab study of vegetation effects on flows and sediment deposition (Lewisville, TX),

c. A field study of denitrification enzyme activity (New England),

d. A study of the usefulness of redox potential electrodes (Cane Bayou, LA), and

e. A study of soil processes in newly created wetland systems (Des Plaines, IL).

Another significant element of the task area was given to the development and application of wetland numerical simulation models. Model development was constrained to the modification of existing

programs to take advantage of successful methodologies and reduce development costs. Three models were developed during the program that are best executed on a main frame computer or work station. A sedimentation model was developed for application to wetlands with fine grain and cohesive sediments. A dynamic hydrology model was developed which accounts for all of the elements of the hydrologic cycle and provides a dynamic means of routing water through the wetland system. A model was also developed for simulating the change in concentration of water quality constituents. Two smaller screening level programs executable on a PC were developed, as well. A water quality model was written which provides a calculation of the gross change in concentration of conservative chemical constituents, and a model was developed that provides estimates of wave characteristics for waves propagating over muddy bottoms.

The development of the larger simulation models was not an end in itself. Our intention was to develop the models to help us understand the processes that occur in wetlands and their effect on functions. The programs were used to support the field study efforts at the Cache River by providing simulated data where (spatially and temporally) measured data was not available. The models were also used to conduct scenarios of wetland change to begin the compilation of information necessary to derive general rules-of-thumb for wetland processes and functions and their responses to system changes.

TASK AREA IV - WETLANDS DELINEATION AND EVALUATION

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The US Army Corps of Engineers is responsible for regulating wetlands under Section 404 of the Clean Water Act. Several critical questions that must be addressed to satisfy that responsibility are: Where is the boundary of the wetland? and What good is the wetland or what functions does the wetland provide? These questions provided the focus for studies conducted in the Task Area on Wetland Delineation and Evaluation of the Corps of Engineers Wetlands Research Program (WRP). The Task Area was stratified into two major work units --- one to examine issues associated with wetland delineation and the technical assumptions incorporated into the techniques to assess wetland boundary definition. The other work unit was designed to examine issues associated with wetland evaluation and assessment procedures in order to develop a technique to assess wetland functions. A brief

description of accomplishments achieved for each of the two work units is provided.

Wetland Delineation

Dr. James Wakeley was the principal investigator for wetland delineation. Studies were conducted to examine several of the technical assumptions of the delineation method and to examine relationships between field indicators and measured hydrology at field sites in different areas of the country. Review of the technical literature revealed that there is little supporting information regarding the use of water-stained leaves as an indicator of the presence of wetland hydrology. On the other hand, formation of oxidized rhizospheres and iron plaques on the surface of roots clearly occurs under reducing conditions and is a strong indicator of wetland hydrology when present. Absence of iron coatings, however, does not imply absence of wetland conditions. Studies in Florida sandy soils showed that presence of muck or mucky-textured mineral material was reliable evidence of hydric soil conditions. Cooperative research with the Soil Conservation Service in 8 states showed considerable variation in timing of soil saturation, anaerobiosis, and reduction of iron in mineral soils. Furthermore, many soils were found to be biologically active and became reduced outside of assumed growing season dates. Studies in New England show that the presence of redox depletions in soils derived from red parent materials is a strong indicator of hydric conditions, as are dominant chroma-3 colors in certain problem soils.

Wetland Evaluation

Mr. R. Daniel Smith was the principal investigator for the work unit on wetland evaluation. Numerous technical and administrative constraints were identified in many of the wetland assessment techniques available at the start of the WRP. A new technique was developed to address these constraints. The technique, referred to as the Hydrogeomorphic Approach to Wetland Assessment, is based on two important components --- classification of wetlands into similar functional types and reference wetlands to calibrate assessment models. Initially a wetland is classified into particular classes and subclasses based on procedures identified in A Hydrogeomorphic Classification for Wetlands (Brinson 1993). Reference wetlands are established for particular wetland types in specific geographic areas to reflect the range of conditions that occur in that area for that type of wetland. Assessment models are developed and calibrated against the reference wetlands. Model output is an index of 0.0 to 1.0 scaled to the reference wetlands and, when multiplied times acreage, provides functional units for assessment of project impacts and mitigation needs. The technique has application in assessing wetland functions for a single wetland or comparison of similar wetland types. It can also be used to assess pre and postproject

impacts and in designing mitigation.

TASK AREA V - RESTORATION, PROTECTION, AND CREATION OF WETLANDS

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The US Army Corps of Engineers expanded its Wetlands Research Program (WRP) in 1990, and included a large research Task Area on wetlands restoration, protection, and creation (RPC). The concept used in developing the task area was to form work units (WU) that complemented each other and followed the decision-making framework developed by the Corps for wetland RPC projects. A strong emphasis on multi-disciplinary teams working in a cooperative relationship with sponsors, other agencies, and the public was also encouraged.

Three major work units were developed:

(a) WU 32758, Improving Design Criteria for Wetlands;

(b) WU 32760, Techniques, Engineering, and Structures for Wetland Restoration and Creation; and

(c) WU 32761, Wetland Field Research Demonstrations.

Multi-disciplinary research teams were formed for each work unit. Corps offices and other agencies were invited to recommend study sites within their jurisdiction. Out of over 240 project sites recommended, 28 were selected and studied in this Task Area during the WRP. WU 32761 was further categorized into eight research areas (RA):

(a) RA 1: Long-term comparison of natural and manmade wetlands, with six field sites at Pointe Mouillee in Michigan, Buttermilk Sound in Georgia, Lower Columbia River in Oregon, Chevron Mitigation Wetland in Mississippi, San Francisco Bay in California, and Aberdeen Proving Ground in Maryland;

(b) RA 2: Wetland engineering in coastal Louisiana, with four field sites studying sediment siphons, artificial crevasses with delta splays, beneficial placement of dredged material, and a marsh management unit developed as a mitigation bank in the Lower Mississippi River delta;

(c) RA 3: Coastal stabilization and erosion control, with four field sites at West Bay and Aransas National Wildlife Refuge in

Texas, Eastern Neck National Wildlife Refuge in Maryland, and Galilee Sanctuary in Rhode Island;

(d) RA 4: Bottomland hardwood reforestation, with two field sites at Kentucky Lake on the Tennessee/Kentucky border, and Lake George in Mississippi;

(e) RA 5: Freshwater depressional restoration, with four field sites at Amazon Channel in central Oregon, Charlotte County Correctional Facility in south Florida, Weaver Bottoms in the Upper Mississippi River, Minnesota, and L-Lake in South Carolina;

(f) RA 6: Freshwater riparian restoration, with three field sites at Cache Slough in California, Jackson Hole in Wyoming, and Green Bottom in West Virginia;

(g) RA 7: Coastal restoration and creation, with four field sites at Lincoln Avenue in Washington, Galveston Bay in Texas, Beaufort in North Carolina, and Winyah Bay in South Carolina; and

(h) RA 8: Unique wetland conditions, with two field sites at Des Plaines in Illinois, and Beaver Creek in Ohio.

Results and accomplishments during the 4-year research effort were diverse and prolific. For example, 30 principal investigators and 42 contractors made nearly 200 technical presentations and/or wrote technical journal or proceedings papers, books and book chapters, and manuals that were published separately from WRP's own series of products. A number of technical reports, technical notes, and other WRP products (including software and videotapes) have been completed, and have either been published or are in draft nearing publication. A series of working draft guidelines manuals are being published, and are being field tested in 1995-1996. These include manuals on design criteria, mitigation, and wetland engineering. Information from this task area has been used in two National Academy of Sciences books, in one interagency engineer manual published and another in draft by the USDA Natural Resources Conservation Service, a NATO study on environmental restoration, and three policy papers published by Washington-based international scientific societies.

The Task also developed the decision-making framework for wetland restoration and creation; design criteria based on the 11 recognized wetland functions; two engineer manuals (one Corps, one interagency) for wetland restoration and creation technology; assessments of the four critical requirements for successful restoration (soils, water, energy, hydrology); a wetland vegetation source list; propagation requirements for numerous wetland species; and research (contract and technical reports) from the 28 Task field site studies conducted during the Program. A national wetland engineering workshop, the first of its kind, was conducted in 1993 by Task staff, and Task members were instrumental in this

national interagency workshop.

TASK AREA VI - STEWARDSHIP AND MANAGEMENT

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The US Army Corps of Engineers (CE) manages more than 11 million acres of land and water owned in fee title on approximately 460 Civil Works projects located throughout the United States. Although natural resource stewardship is an inherent objective of managing these lands, the recent national emphasis on the ecological importance of wetlands highlighted a need for greater attention to wetland resources on CE projects. CE field elements identified a particular need for the development of improved techniques for wetland management.

The primary objective of Task Area VI was to develop integrated guidelines for the management of CE wetland resources. Emphasis was on project lands under CE jurisdiction. Six major work units (WU), shown below, were developed for the task area. Multi-disciplinary research teams were formed for each work unit. All studies stressed partnering and interagency cooperation.

WU 32763 - Automated Analysis, Display and Information Bases for Wetland Systems

WU 32762 - Techniques for Characterizing Changes to Wetland Systems

WU 32766 - Wetland Stewardship and Management Demonstration Areas

WU 32765 - Technology for Managing Wetlands

WU 32757 - Cumulative Impact Analysis

WU 32764 - USACE Wetland Decision Support System.

WU 32763 was established to demonstrate the application of automated information base technology to the organization and management of wetland environmental data. A combination of geographic information system (GIS) and relational database management system technologies was used to develop a prototype information base designed to support all aspects of wetland system research and management. The system integrated spatial data such as land-use maps and multi-temporal satellite images with tabular

data.

WU 32762 was designed to evaluate the potential for using remote and field-based technologies to assist in assessing changes to wetland systems. Emphasis was placed on isolating cost-effective technologies and methods for District and project offices. Remote sensing, GIS, and global positioning systems were evaluated, and selected techniques were applied to test sites. A multi-agency workshop was held at the Waterways Experiment Station to exchange information and conduct interagency training.

Interdisciplinary research teams designed and implemented projects on 16 demonstration sites as part of WU 32766. Topic areas investigated were non-point source pollution, sediment management, vegetation management, wildlife habitat management, fisheries habitat management, natural communities/biological diversity, pest management, and wetland systems management. Field studies were designed to test and improve a variety of strategies and techniques to improve wetland stewardship and management on CE projects. Technologies emphasized coordinated, landscape-scale approaches and solutions to management problems.

Existing and newly emerging techniques for wetland management were identified, evaluated, and documented for WU 32765. Research topic areas were identical to those in WU 32766. Technologies within these areas were evaluated in respect to cost effectiveness and potential application for improving wetlands at CE projects. Technology transfer products developed for this work unit include a plant materials handbook and a handbook of wetland management techniques. The techniques handbook will be part of a guidance manual series being prepared for the WRP.

WU 32764 focused on identifying means to describe, quantify, and isolate the historic hydraulic and hydrologic influences on a wetland. Research included testing applications of indices and summaries derived from flow and/or stage records to wetlands of the Cache River, Arkansas. Cumulative impacts were assessed for conditions and processes likely to affect wetland vegetation, wildlife, and aquatic biota. Harmonic analysis and other techniques were employed to reveal time-frames when disruption to basic flow patterns may have occurred. Climatic patterns were analyzed to differentiate between human-induced and natural changes in hydrology, and human influences were described from groundwater and land-use data.

The objective of WU 32764 was to develop a conceptual decision support system designed to facilitate the storage, evaluation, and communication of wetlands information among CE offices. A survey was conducted of approaches and management models used by other agencies and organizations, and an evaluation was made for potential wetland resource management applications. The US Fish and Wildlife Service Moist Soil Management Advisor is being

examined for application to CE management scenarios.

Most of the work for the Stewardship and Management Task Area was accomplished through extensive partnering with other agencies and organizations. Cooperators included 12 CE Districts, 19 CE project offices and other facilities, 30 offices representing 7 other federal agencies, 11 state agencies, 4 local governments, 6 conservation organizations, and 4 private businesses. Products for the task area were highly diverse and included WRP Technical Reports, WRP Tech Notes, WRP guidance manuals, newsletter and bulletin articles, journal articles, symposium proceedings, other-agency reports, and MS/PhD theses. Numerous papers were presented at workshops and symposia.

SESSION RE1

RESTORATION, PROTECTION, AND CREATION:
FRESHWATER WETLAND CREATION AND RESTORATION
IN THE NORTHEASTERN UNITED STATES
Leonard Houston, Chair

HUDSON RIVER ENVIRONMENTAL RESTORATION PROJECT

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The Hudson River Environmental Restoration Project (HRER) is a cost-shared study of the US Army Engineer District, New York, and the State of New York Department of Environmental Conservation. HRER is an area of considerable concern to the citizens of New York State, because the Hudson River Valley has been impacted and changed by over 200 years of commercial and other activities. Approximately 2800 acres of riverine habitat has been filled, much of it through past Corps practices of diking along riverbanks and islands and placing dredged material. Construction of the railroad system along both banks has also been a major source of habitat disturbance in limiting or modifying circulation patterns in back bay and shallows areas.

How to restore, what are the major priorities, when should work be scheduled, and how will it be funded are four of the challenging questions the Corps and the State are working to answer. The Corps just completed a federal reconnaissance study of the Hudson River that should lead to a feasibility design study and construction, which would have shared state funding.

As part of the reconnaissance study, the Corps formed a HRER technical working group that consists of state, federal, and local agency representatives, citizens groups, and New York State conservation organizations. The Corps conducted several interagency boat and vehicle field efforts for the HRER technical working group and evaluated historic and current aerial photographs. It also mapped intact and failed infrastructure in the HRER (bulkheads, culverts and trestles, bridges, dredged material placement sites, marinas/boat landings, old industrial sites, island roads, and special environmental features such as eagle nests) in a comprehensive effort to determine needs and impacts in the HRER.

The Corps also conducted a 2-day technology and information workshop attended by over 200 agency representatives and citizens. The workshop had the dual purposes of finding out what citizens and conservation groups envisioned for the HRER, and of providing technical information them on the history, background, current study, and potential restoration approaches being evaluated. Technical experts familiar with problems similar to those found in the HRER, each specializing in areas such as hydrology, engineering, soils and geology, vegetation, rehabilitation of highly disturbed lands, and ecological restoration, made presentations and held an open information exchange forum.

Major highlights of the HRER is the unusually cooperative atmosphere among interested parties under which the study is being conducted, and the intense desire of these same people to accomplish riverine and wetland restoration using sound science and engineering principles. The next step in the HRER is the undertaking of a feasibility design study, that will include cooperative funding and shared-work pilot projects on carefully selected sites along the Hudson.

CREATION OF FORESTED WETLANDS ON GRAVEL MINED SITES CONSTRUCTION AND IMPLEMENTATION

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Gravel pits are disturbed or degraded landscapes that often have a groundwater hydrology suitable for pond and marsh wetland creation. Techniques for developing these sites to pond-marsh wetlands are simple and, in the northeast at least, might be considered routine. Groundwater elevations are monitored (wells) for at least one year. The excavation intersects the groundwater table to the desired depth usually 6 feet or more. Slopes along the pond edge are kept as gradual as possible, approximately 1 to 10 slope, so that an emergent wetland edge can develop in shallow water. Islands and a sinuous shoreline are incorporated into the design to increase diversity. Because the sand and gravel substrate is a poor plant growth media, a top dressing of humus, preferably from a wetland is spread in the shallow water or marsh zone. The wetland may be planted, however, vegetation develops primarily from natural seed germination present in the humus or blown onto the site (Garlo 1993; Podgett and Crow 1995). The biggest problem is invasive species that colonize disturbed sites such as purple loosestrife (Lythrum salicaria) and common reed (Phragmites australis). It is important that any soil materials brought onto the site do not contain seeds of nuisance species.

A condition of the Army Corps 404 permit issued in 1992 for the New Hampshire Route 101 highway improvement required the creation of 105 acres of wetland at the "Pine Road" gravel pit site, a majority of which would be forested wetlands dominated by red maple (Acer rubrum) similar to those impacted by the project. During the summer of 1994, 500,000 cubic yards of material was excavated to create approximately 40 acres of a diverse pond-marsh-forest wetland.

A mound-and-pool microtopography similar to that found in natural red maple swamps in the region was constructed around the marsh zone. This microtopography probably occurs naturally from the combined effects of rootmounds raised up by windthrown trees and the tendency for plant roots to seek an oxygenated environment in saturated soils. This elevational diversity is an important microsite condition for plant establishment and growth given the dynamic water table fluctuations both seasonally and year-to-year in red maple swamps. Reports of the relationship of hydrology and microtopography in several red maple swamps (Allen et al. 1989; Golet et al. 1993) were used to develop the construction guidelines, which called for an average of 2 feet elevation difference between the high areas of the mounds and the low areas of the pools. The mounds were spaced on average 20 feet apart. The slope of the forested wetland must be more gradual (1 to 20) than is acceptable for pond-marsh created wetlands. Also a better understanding of the site's water table fluctuation is necessary to determine elevations at which to construct the forested wetland microtopography. This is especially important because control structures often cannot be used to control water levels in freely permeable sand and gravel aquifers.

The mound-and-pool microtopography was constructed in the subsoil by a D6 bulldozer raising and lowering its blade, leaving deep gouges which alternated with the mounds on subsequent passes. Tracking over this roughly shaped relief with the D6, then spreading the top dressing with a D3 bulldozer and again tracking over with the D6 efficiently applied an 8-inch layer of wetland humus and resulted in a diverse and somewhat random or natural appearance to the microtopography. It should be noted that on this site the sand and gravel substrate was very easy for heavy equipment to work on even when saturated. Lower load bearing equipment may be required for less stable substrates. During the spring of 1995 shrub and sapling plantings will be done with species placed on the mounds or in the pools depending on their flood tolerance.

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THE ENHANCEMENT OF CAPILLARY FRINGE MOISTURE RETENTION THROUGH SUBSOIL MODIFICATION IN A CREATED WETLANDS

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Background

Developing reliable hydrology within created wetlands is particularly difficult in alluvial soils, and systems fed primarily by groundwater. In-season water table fluctuations and seasonal depletion of soil moisture, can hinder development of diverse plant communities. Inadequate hydrology has been a primary cause of failure of many constructed wetlands sites to date (USFWS 1992).

Excavation and outlet design can reduce the amplitude of watertable fluctuations (Garskof 1993), however plant available moisture can be critically depleted as watertables continue to drop during summer months. This study proposes to increase plant available moisture by increasing the capillary fringe above a watertable, through subsoil modification.

The first of two methods proposed is the replacement of existing sandy and gravely subsoils with finer textured subsoils. Soil texture (porosity) can significantly affect the height of capillary fringe column above a water table (Gerla 1992); and finer texture soils (i.e. loams) will generally contain more total and plant available moisture than coarser soils (i.e. sands and gravels).

The second method proposed is compaction of both the native and replacement subsoils to alter structural composition. Through compaction, pore composition is modified so that total moisture

content and available soil moisture is enhanced in some soil types at high suction or low matrix potential; conditions encountered during watertable drop. (Gupta et al. 1989, Williams 1993).

Study Design

The study area, is a 3.2 alluvial site, adjacent to Bald Eagle Creek, Clinton County, PA. Mapped soils, Linside and Huntington are deep and well drained, with surface textures ranging from silt loam to sandy loam; with sands and gravels in underlying strata. Excavation of 10 backhoe pits confirmed sufficient sandy loam and silt loam for the subsoil replacement study.

Groundwater (gw) monitoring wells were installed and monitored between 5/1992 - 10/1993, indicating 4-5' in-season watertable fluctuations. Outlet design and excavation was proposed to limit in-season basin flooding, while providing variable saturation to the surface along a gently basin gradient (approx. 50:1 slope), with a 1.5 foot elevational rise.

Threats of high gw during construction were addressed with upslope perimeter ditches, with pumping to sedimentation basins and creek discharge. Stream overflow could cause work stoppages but such events would likely be infrequent and of short duration.

Eight study "strips" were proposed within the study area (Fig. 1). Four areas will be excavated down to 24" below final grade so that 18" of sandy loam and 18" of silt loam subsoil can be placed below the topsoil in each of two strips. Three strips will serve as control areas with native subsoils intact.

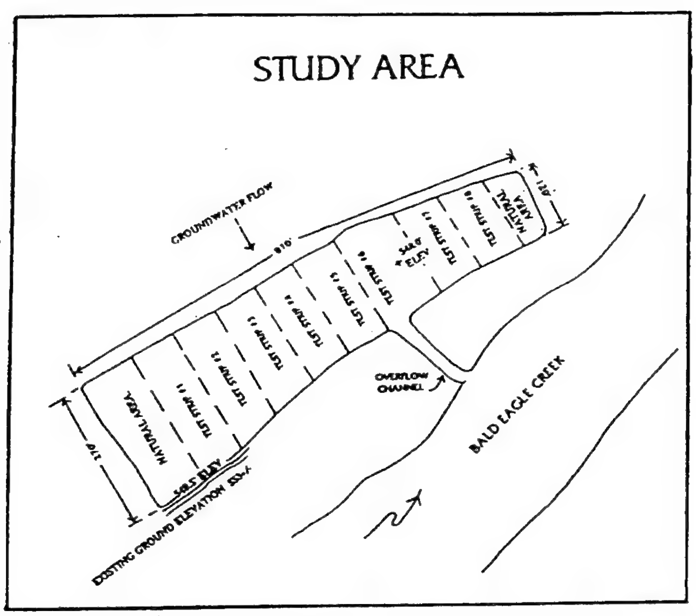

FIGURE 1

An intensive study area in the final strip will contain 36" diameter tubes at various elevations, filled with compacted or non-compacted subsoils. This area provides greater control over characterization of replacement subsoils, compaction rates and water tables thereby providing greater accuracy in correlating findings with site conditions.

Soil moisture within the study strips and tubes will be measured using a neutron probe. Findings will be correlated with vegetative indicators including total cover, and plant community composition and diversity.

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EFFECTS OF HYDRIC VERSUS LOAM BACKFILL ON SURVIVORSHIP AND COMMUNITY COMPOSITION IN A MITIGATION SITE IN CENTRAL CONNECTICUT

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Introduction

To compensate for the unavoidable loss of wetlands resulting from the construction of Route 9, Central Connecticut Expressway, the Connecticut Department of Transportation and Metcalf & Eddy designed and constructed 5.1 acres of palustrine wetlands in 1992. The compensatory wetlands were constructed as two basins (6HE and 6HW), each of which were divided into four study plots, with 2 plots backfilled with loam soil and two with hydric soils. Vegetative monitoring results from 1993 and 1994 document the influence of soil type on propagule survivorship and herbaceous community composition.

Methods

Annual mitigation monitoring was conducted in July 1993 and July 1994. Data collected included survivorship and reproduction for each of the 407 plantings in basin 6HE. For shrubs, trees, and shrubs and trees combined, log-linear analyses were used to test for interactions of survival and reproduction with soil type (hydric or loam) and species. In addition, eight 10m x 10m and 16 4m x 4m vegetation sampling quadrats were established in basin 6HE and 6HW, respectively. Data collected included species composition and areal coverage of herbaceous species within each of the permanent quadrats. Chi-square analyses of community statistics and cluster analyses of community data were conducted.

Results and Discussion

The over-all survivorship of propagules was high, exceeding 90% for trees and shrubs in basin 6HE since 1992. Survivorship was slightly higher for green ash plantings than for red maple and the probability of survivorship of trees was not influenced by soil type (hydric or loam). Among the shrubs, survivorship was similar, ranging from 85 to 95%. In both 1993 and 1994, shrub survivorship was greater on hydric soils than loam soils (Table 1). Differences among individual shrub species for improved survivorship on hydric soils was not detected.

The mean vegetative cover of the herb layer was 100% in basin 6HW and 83% in 6HE in 1994. There was no significant influence of soil type (hydric versus loam) observed among quadrats for total cover, percent hydrophytic species, diversity, evenness or dominance. There was a higher percentage of hydrophytic species on the hydric soil plots in basin 6HW, however, the effect was not significant. In both basins similarity analyses indicated an influence of soil type on the community composition of the herb layer. Results indicated that both soil type and spatial locations of the quadrats had an influence on species composition in the herb layer. Sample quadrats in close proximity, and consequently with similar hydrology, had the most similar community compositions.

Table 1. Log-Linear Analyses Results for Propagule Survirorship and Reproduction in 1994 at the Central Connecticut Expressway Mitigation Site, Basin 6HE.

Group	Interaction	Significant	Explanation
Shrubs	Survival * Species	No	Survival was not influenced by shrub type. Survivorship among shrubs (southern arrowwood, highbush blueberry, spicebush) was similar.
	Survival * Soil Type	Yes	Survival was influenced by the soil type on which a shrub was planted. Survivorship of shrubs was higher on hydric soils than on loam soils.
	Reproduction * Species	Yes	Reproduction was influenced by shrub type. Percent reproduction rankings, from highest to lowest, were as follows: highbush blueberry, southern arrowwood, spicebush.
	Reproduction * Soil Type	No	Reproduction was not influenced by the soil type on which a shrub was planted. Shrub reproduction rates were similar on hydric and loam soils.
Trees	Survival * Species	Yes	Survival was influenced by species type. Survivorship was higher for green ash than red maple.
	Survival * Soil Type	No	Survival was not influenced by the soil type on which a tree was planted. Tree survivorship rates were similar on hydric and loam soils.
Shrubs/ Trees	Survival * Species	Yes	Survival was influenced by species. Survivorship rankings of trees and shrubs, from highest to lowest, were as follows: southern arrowwood, green ash, red maple, highbush blueberry, spicebush.
	Survival * Soil Type	Yes	Survival was influenced by the soil type on which individuals were planted. Survivorship of shrubs was higher on hydric soils than on loam soils. Survivorship of trees was similar on hydric and loam soils.

Two of the soil plots (one hydric, one loam) in basin 6HW were hydroseeded in 1992. In the first year after construction, the total cover was not enhanced by seeding, but the proportion of vegetative cover contributed by hydrophytic species was lower on hydroseeded plots after one growing season. By the second year of monitoring, there was no observable effect of hydroseeding on cover or community composition. After 2 years of monitoring, hydric soil backfill resulted in slightly higher survivorship of shrubs, and minor influences on community composition of herbaceous vegetation.

CONSIDERATIONS FOR CREATION OF A SPARTINA SALT MARSH IN THE NORTHEAST

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The Massachusetts Port Authority (Massport) was required by the FAA to construct a runway safety ramp on Logan International Airport which involved the filling of approximately 9,000 sf of *Spartina alterniflora* salt marsh in the Wood Island Marsh area of Boston Harbor. A 0.52 ha (56,250 sf) salt marsh was constructed near the safety ramp as part of the mitigation for the salt marsh fill.

The salt marsh design, collaborated on by Jason Cortell and Associates, The BSC Group and Great Meadow Farm incorporated experimental techniques including the construction of pannes and channels at specific locations, elevations, and widths to support colonization of shellfish, with particular attention to creating the habitat of ribbed mussels (*Geukensia demissa*), which will contribute to a sustainable nitrogen cycle. Deep channels retaining water were designed to create juvenile finfish habitat. The entire marsh was encompassed with channels to allow for tidal flow which will control the spread of the (*Phragmites australis*) plant communities adjacent to the site and will assist with nutrient cycling, control algae growth, and reduce wrack deposition.

Planting zones for the tall, medium and short *S. alterniflora* and *S. patens* were established based on growing patterns in the adjacent marsh. *S. alterniflora* donor stock was transplanted from the fill area and was supplemented by nursery stock brought in from Great Meadow Farm. The *S. alterniflora* was planted between 2.0 and 4.7′ NGVD and were planted in a specially prepared topsoil or the existing clay substrate. *Spartina patens* nursery stock was planted at the higher elevations of the marsh (4.7′and above).

A five year monitoring plan is evaluating plant species composition, plant density, stem height, biomass production, growth of plant shoots from rhizomes, soil development and colonization of shellfish. The channels and pannes are monitored for water salinity and temperature, plant species diversity, finfish habitation, shellfish colonization and movement of these structures.

Results from the first year of monitoring indicate several trends in the marsh. Benthic holes and populations of mud dog whelk (Nassaria obsoleta), mummichog (Fundulus heteroclitus) and three spine sticklebacks (Gasterosteus aculeatus) were found in the channels and pannes even before construction completion. Shore birds such as snowy egrets (Egretta thula) and greater yellowlegs (Tringa melanoleuca) immediately began feeding on the snails and fish. A soft shell clam (Mya arenaria) population, with individuals approximately 1.0 to 1.5 cm in length was found throughout the marsh in the fall. No live ribbed mussels have been found.

Approximately 97% of the S. alterniflora donor and nursery plugs were successfully transplanted. As illustrated in the following table of plant plots in the created marsh, the donor stock S. alterniflora (Plot A) produced 230% more dry biomass, were 128% taller and produced 900% more root shoots than the nursery stock (Plot C) at a similar elevation. The nursery S. alterniflora in the mixed topsoil (Plot C) produced 19% more biomass were 3% taller and 1 less root shoot than the nursery stock planted in the clay substrate (Plot E).

Plant Plots in Created Marsh	Elev. (ft., NGVD)	Biomass (dry, g/m^2)	Stem Height (ave. in cm)	Root Shoots
Plot A donor *S. alterniflora* in topsoil	4.2	16.4	53.3	20
Plot B nursery tall *S. alterniflora* in topsoil	3.4	35.44	74.3	19
Plot C nursery medium *S. alterniflora* in topsoil	4.3	4.96	23.4	2
Plot D nursery short *S. alterniflora* in topsoil	4.7	7.14	22.3	9
Plot E nursery medium *S. alterniflora* in clay	4.0	4.16	22.8	3
Plot F nursery *S. patens* in topsoil	4.9	0.01	12.1	0
Plot G nursery *S. patens* in topsoil	4.7	0.01	11.4	0

The S. patens did not transplant well and S. alterniflora and Distichlis spicata have begun to colonize the S. patens areas as expected based on previous research. One P. australis shoot also sprouted within the S. patens planting area and reached a height of 45 cm. Algal growth reached 65% cover in the created marsh and all of Wood Island Marsh by November and after a northeast storm on February 4, the algal cover dropped to 20% in the created marsh.

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SESSION RE2

RESTORATION, PROTECTION, AND CREATION: ENGINEERING AND GEOGRAPHIC INFORMATION SYSTEMS

Mary C. Landin, PhD, Chair

HYDROLOGICAL RESTORATION OF WETLANDS BY HYDRAULIC MODIFICATIONS

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The St. Johns Marsh Conservation Area (SJMCA) is a 28,500-acre marshland located in the headwaters of the St. Johns River, Florida (Fig. 1). Since the early 1900s, this valuable wetland has been encroached upon by agricultural activities, and drainage canals have been constructed for rapid conveyance of flood waters. As a part of a $185 million federal flood control project, the St. Johns River Water Management District (SJRWMD) is attempting to restore historical hydrological functions within SJMCA. The SJMCA is bounded by levees on the eastern and southern boundaries (Fig. 1). The western boundary, however, is composed of pieces of abandoned levees, and a drainage canal, where run-off from the St. Johns River tributaries enters the SJMCA without interruption. These lateral inflows account for about 5% of the total discharge in the area. The remaining discharge enters the area from the south and flows north. A large portion of the discharge used to be conveyed by the drainage canals along the eastern and western boundaries.

The plan to construct canal plugs is included in the US Army Corps of Engineers General Design Memorandum. A canal plug is an earthen structure built across the width of the canal. The purpose is to stall the flow or divert the flow laterally so that water would spread into the marshland. The SJRWMD constructed seven plugs in the eastern canal and one in the western canal in 1987 (W1, and E2 through E8, Fig. 1). To ensure proper functioning, some of the plugs are constructed for more than 1000 ft in length. The project was successful and the condition of SJMCA has been improved to satisfy the environmental hydrological criteria. The environmental hydrological criteria have been developed as a guide for restoration and protection of wetland habitats (Miller et al. 1993). These criteria relate to mean water depth, frequency of inundation, maximum elevations, minimum range of fluctuation, timing of fluctuation, water level recession rates, and minimum water levels. Among them, the mean water depth is an important criterion.

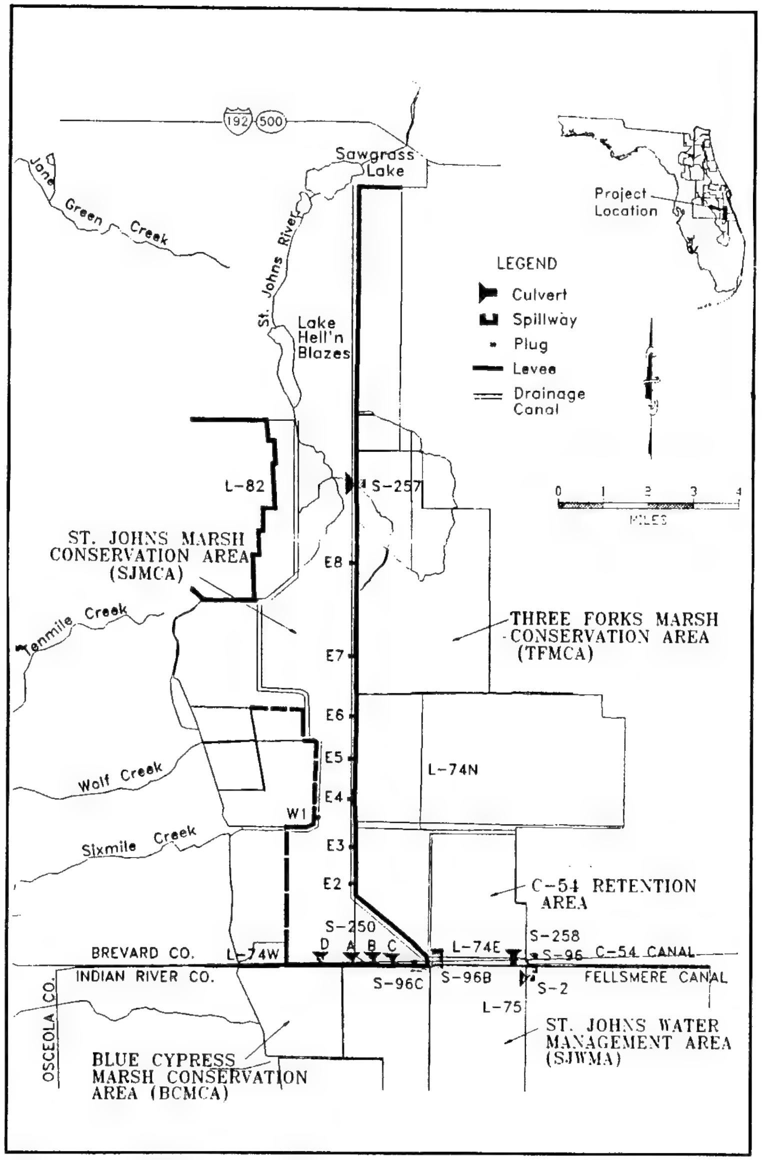

Fig. 1. Project Location.

Fig. 2. Simulated Water Depth Contours.

With the completion of canal plugs in 1987, and construction of various components of the federal flood control project since 1988, run-off conditions have improved in the SJMCA. Hydrological data have been collected to evaluate changes of the system. To generate long-term data that includes impacts of federal flood control project, a continuous hydrological simulation model was used. For the SJMCA, a two-dimensional finite element model (US Army Corps of Engineers, RMA2, 1993) was calibrated for the existing conditions. The model was used to calculate water depth distributions of existing and pre-plug conditions. The results show that the canal plugs have increased mean water depth in the SJMCA (Fig. 2). The model can be modified to simulate any other flow conditions and, therefore, can be used in design of any additional hydraulic modifications in the future.

References

Miller, S.J., Lee, M.A., Borah, A.K., and Lowe, E.F. "Environmental Water Management Plan for the Upper St. Johns River Basin Project." Draft, May 1993, St. Johns River Water Management District, P.O. Box 1429, Palatka, FL 32178-1429.

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ASTM STANDARD GUIDE FOR WETLAND ASSESSMENT, DESIGN, AND CONSTRUCTION

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The American Society of Testing and Materials (ASTM) is developing a Standard Guide for wetland functional assessment, terminology, and design and construction. The Guide is being prepared by volunteers from the E50.05 Subcommittee of ASTM Committee E50 on Pollution Prevention, with technical review and comment by nationally-recognized wetland experts.

The purpose of the Standard Guide will be several-fold:

1. To introduce standard definitions for common wetland terminology;

2. To develop standard descriptions of wetland ecological functions;

3. To provide an approach for assessment of existing and planned wetlands for any objective;

4. To provide standards for wetiand planning, design, restoration, creation and enhancement.

5. To provide a general approach for monitoring planned wetlands.

The following organizations, with a broad range of interests in wetlands, have provided funding to assist in the development of the Guide through the ASTM Institute of Sponsored Research (ISR):

Electric Power Research Institute
Empire State Electric Energy Research Corporation
Federal Highway Administration
National Association of Realtors
Target Stores

ASTM is a not-for-profit organization which provides a forum for producers, users, ultimate consumers, and those having a general interest (representatives of government and academia) to meet on common ground and write standards for materials, products, systems, and services. ASTM standards are developed voluntarily by consensus and used voluntarily. Standards become legally binding only when a government body references them in regulations, or when they are cited in a contract. An ASTM standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn.

The term standard serves in ASTM as an adjective in the title of documents, such as test methods or specifications, to connote specified consensus and approval. A guide, as used in ASTM, is a series of options or instructions that do not recommend a specific course of action.

Efforts to develop a Wetlands Standard Guide have been underway by Subcommittee E50.05 since 1992, when the national debate over the various federal manuals for jurisdictional wetland delineation led to the awareness of a general uncertainty regarding ways to evaluate wetlands and to develop appropriate mitigation guidance. Since then, rapid growth in wetland construction for ecological benefit and water quality improvement has created additional needs for technical guidance. Subcommittee E50.05 currently consists of 239 members (136 with voting status) who include environmental consultants, lawyers, realtors, banks,

industry, government, and academic research.

The Standard Guide is expected to be a valuable tool to wetland practitioners, development interests, and government regulatory and wetland management agencies because they will be educational, widely available, consensus-based, technically current, and a common ground for addressing wetland planning issues.

USING GEOGRAPHIC INFORMATION SYSTEMS TO IDENTIFY AND PRIORITIZE POTENTIAL WETLAND RESTORATION SITES IN COASTAL NORTH CAROLINA

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The North Carolina Division of Coastal Management (DCM) has developed an automated GIS methodology to locate high priority wetiand restoration sites on the North Carolina Coastal Plain with the goal of increasing the ecological effectiveness of wetland restoration and compensatory mitigation. The procedure utilizes ARC Macro Language programs in ARC/INFO accessing data such as SCS digital soils, National Wetlands Inventory (NWI), USGS hydrography, and Landsat Thematic Mapper (TM) satellite imagery to locate and prioritize potential wetiand restoration sites. Areas identified as potential wetiand restoration sites fall into three general categories: 1) areas with hydric soils and TM land cover identified as cleared agricultural or other disturbed areas (including areas identified as wetlands by the NWI); 2) areas with hydric soils and identified by the NWI as ditched, impounded, excavated, or spoil areas; and 3) NWI uplands with hydric soils and dense pine monoculture TM land cover.

Ecological parameters determined through existing data are used to prioritize sites. Parameters considered include:

1. Connectivity and proximity to other wetlands riparian areas, and water bodies;

2. Floodwater runoff storage and peak flow attenuation in coastal watersheds;

3. Non-point source pollution removal and transformation potential based on surrounding land uses;

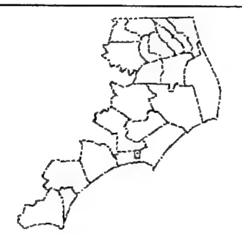
4. Re-establishment of wildlife habitat, forest interiors, and dispersal corridors;

Figure 1: Potential Restoration Site Map

NEWPORT, NC: HYDROLOGIC UNIT 218

NC SPCS Zone 4901, NAD 27

0 1 2 MILES



Created 10 Feb 95

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For more information contact
NC Div of Coastal Mgmt

N

Marsh	Wet Flatwoods	NWI "d" Modifier Only
Est SS/FO, Maritime	Pocosin	NWI Impounded Area
Swamp / BLH	Drained and Cleared	NWI Excavated / Spoil Area
BLH / Headwater	Managed Pinelands	Open Water

Rivers/Streams
Primary Roads
Secondary Roads
HU Boundary

5. Potential for enhancement of anadromous fish nursery areas;

6. Proximity to water supply watersheds, surface water intakes and support threatened water bodies;

7. Sediment and toxicant retention potential and;

8. Potential for replacement of specific functions lost to development.

Ecological parameters are analyzed using automated procedures for each potential wetland restoration site within small watersheds (5000 to 50,000 acres) to target sites with the greatest potential for the replacement of specific water quality, hydrologic, and habitat functions. A variety of functional replacement options may be explored when the procedure is utilized in conjunction with DCM's GIS-based landscape scale functional assessment procedure for existing wetlands (see Wuenscher et. al this volume). Both procedures may be performed for an entire watershed in a few hours.

Preliminary statistical analyses of field verification suggest that over 70% of those areas identified as a potential restoration site for a given wetland type were indeed potential wetland restoration sites which formerly supported that wetiand type. Maps of potential restoration sites are designed to indicate both current land use and the type of wetland which should be restored on a particular site based on soil series and landscape position (Figure 1).

Using a systematic approach in compensatory mitigation site identification increases the probability of successfully replacing lost ecological functions. Compensating for lost functions outweighs availability concerns as the focus of the screening process when a large pool of potential wetiand restoration sites are identified. Permit applicants with projects including unavoidable wetland impacts are guided to sites with the greatest functional potential and are relieved of a burdensome and often disorganized search for a satisfactory restoration site.

SHALLOW-WATER TERRACE CONSTRUCTION REQUIREMENTS

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Abstract

A shallow-water terrace system is a series of earthen embankments with planned openings constructed in shallow ponds, lakes, and bays. The need for a low-cost, durable method to increase the functional wetland value of existing shallow-water areas has led to the development of this standard. Two types of systems are addressed by the standard: the parallel grid system and the shoreline/contour system. The standard is applicable to terraces constructed with bucket equipment or with a terrace plow.

Introduction

The coastal marsh of South Louisiana is dotted with small shallow open bodies of water. The majority of these areas are increasing in size due mainly to tidal surge and wave action. The need for a low-cost durable method to increase the functional wetland valve of these shallow ponds, lakes or bays, has led to the development of new practice called "shallow-water terracing".

A terrace system is a series of parallel earthen embankments that are constructed with planned openings. The openings provide for the natural ingress and egress of marine organisms and water exchange. The system consists of primary and secondary terraces. A primary terrace is a terrace constructed perpendicular to the prevailing wind or parallel to the existing shoreline or on an elevation contour. A secondary terrace is a terrace that is constructed perpendicular to a primary terrace (Figure 1). The construction requirement or standard was developed for terraces constructed in water depths of 24 inches or less with existing on-site soil material.

Purpose and Benefits

The primary purpose of a shallow-water terrace system is to increase the functional value of an existing wetland. The potential benefits to be obtained from the installation of a terrace water system are: (1) reduced open-water fetch length, (2) reduced shoreline erosion, (3) reduced water turbidity, (4) increased water-to-land interface, (5) increased potential vegetation, (6) decreased water velocity, (7) decreased tidal surge, (8) increased sedimentation, (9) decreased water depth, (10) increased submerged aquatic vegetation and (11) providing fishery habitat. The designer should strive to obtain as many of these benefits as possible when designing and installing the terrace system.

Design

An on-site investigation of potential sites should be made by a qualified soil scientist. In reference to the "Unified Soil Classification System", CH and CL material are best suited with OH and OL being poorly suited for terrace construction. The constructed terrace cross section should meet the minimum

requirements of Table 1.

Table 1. Terrace cross section construction requirements.

Soil Type	Water Dpt. "D" (ft)	Minimum Top Wdt. "W" (ft)	Minimum Const. side slope "s" (ratio)	Minimum [1]Freeboard "H_f" (ft)	Minimum [3]Berm "B" (ft)	Minimum Settlement "H_s" (%)
[2]Mineral	0.0-1.0	0	3.5:1	D/3	0	30
(ML, CL,	>1.0-1.5	2	2.0:1	D/3	4	30
CH, MH)	>1.5-2.0	4	2.0:1	D/3	6	30
[2]Organic	0.0-1.0	0	5.0:1	D/3	2	40
(OL, OH)	>1.0-1.5	2	4.0:1	D/3	4	40
	>1.5-2.0	4	3.0:1	D/3	6	40

[1]For wind velocities less than or equal to 40 mph, water depths less than or equal to 2 ft and a fetch length less than or equal to 1,000 ft.

[2]Symbols denote soil type from the "Unified Classification System."

[3]A berm is not required for mineral type soil if adjacent borrow area(s) are 2 ft or less in depth.

The height (H_t) of the constructed terrace (Figure 2) is the sum of the water depth (D) at the construction site, the larger of the minimum freeboard (H_f) from table 1 or the calculated wave height generated by wind velocities in excess of 40 mph, and the allowance for settlement (H_s). The borrow area should have the same side slope as the terrace and be as shallow as practical. The distance between terraces depends on the intended purpose of the system and physical size and configuration of the waterbody. The maximum distance between terraces should be 1,000 ft. The maximum length of a terrace should be 1,000 ft. which includes a 100 ft. opening at the end of each terrace. For shorter terraces the opening should be 10% of the terrace length. The minimum opening shall be 20 ft. Terraces should be staggered so that the openings between each terrace is located approximately at the midpoint of the adjacent terrace. Care must be taken to provide sufficient openings to prevent excessive flooding of the surrounding marsh area. Once a terrace is constructed to the designed height and section it should be vegetated as soon as weather and soil conditions permit.

SHORELINE/CONTOUR SYSTEM

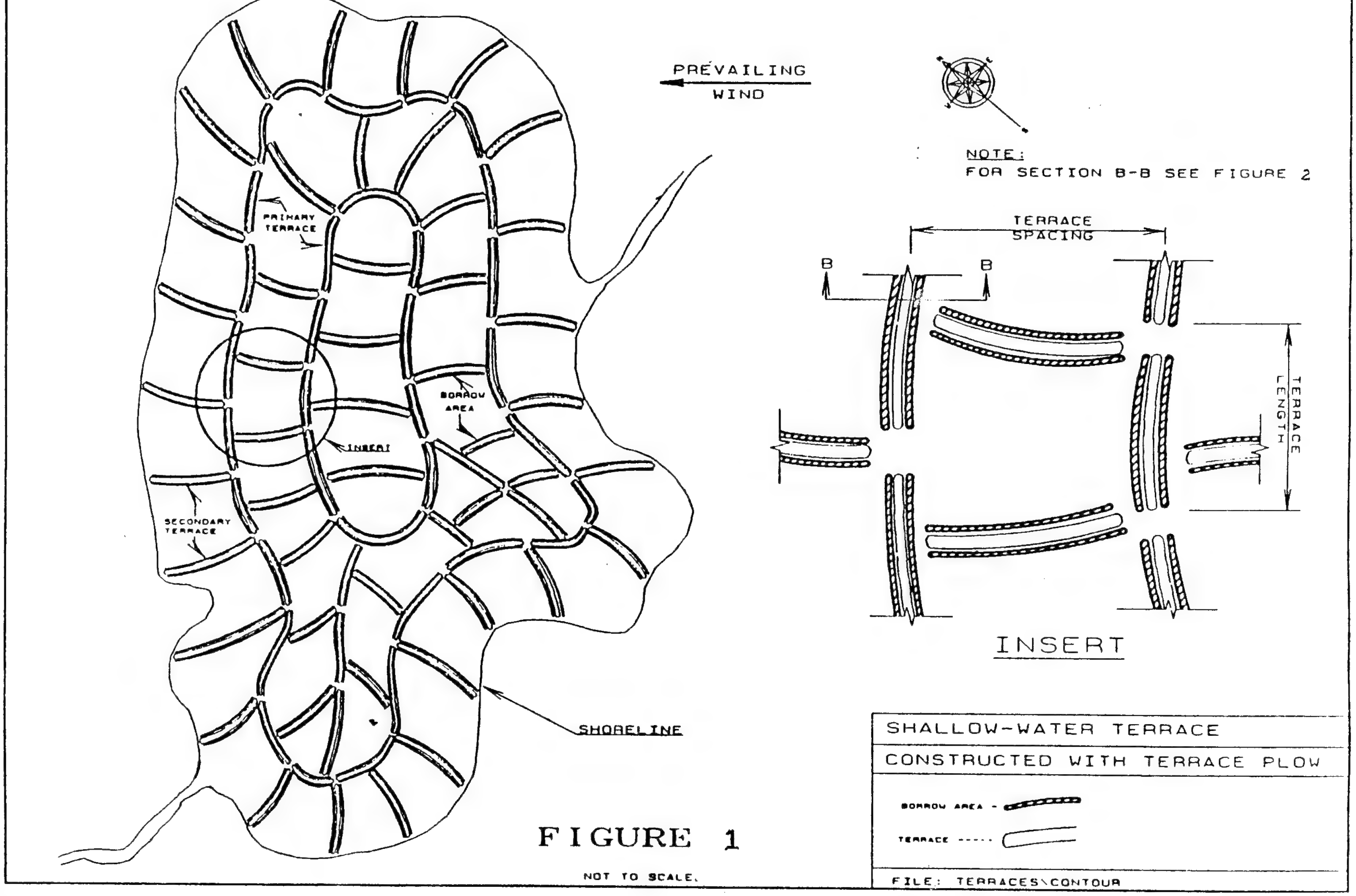

FIGURE 1

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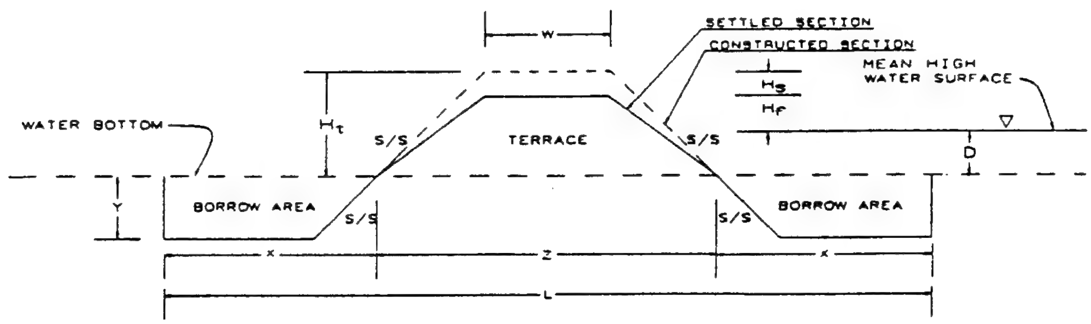
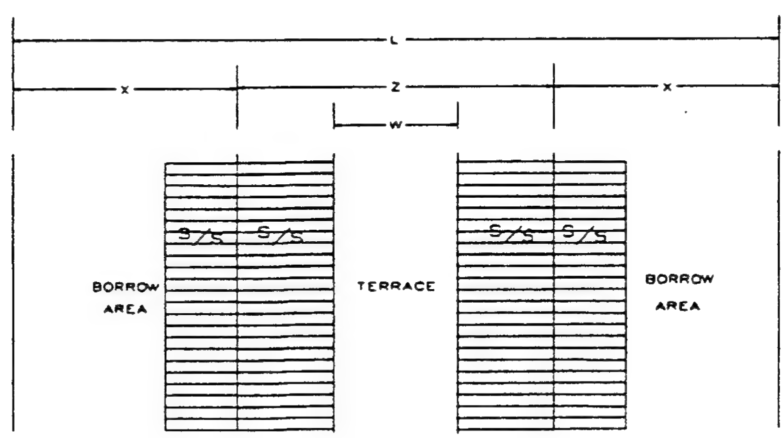
SECTION THROUGH TERRACE

CONSTRUCTED WITH TERRACING PLOW



SECTION B – B

SYMBOL		MEANING	NORMAL RANGE
D	=	WATER DEPTH	0.5 TO 1.5 FEET
W	=	TOP WIDTH	0.0 TO 2.0 FEET
S/S	=	CONSTRUCTED SIDE SLOPE RATIO	1.0 VERT./2.0 HORZ. TO 1.0 VERT./5.0 HORZ.
Hf	=	HEIGHT ADDED FOR FREEBOARD	0.2 TO 0.5 FEET
Hs	=	HEIGHT ADDED FOR SETTLEMENT	0.3 TO 0.8 FEET
Ht	=	TOTAL CONSTRUCTED HEIGHT	1.0 TO 2.8 FEET
X	=	BORROW AREA WIDTH	4.0 TO 20.0 FEET
Y	=	BORROW AREA DEPTH	0.5 TO 2.0 FEET
Z	=	TERRACE WIDTH	7.0 TO 25.0 FEET
L	=	CONSTRUCTION WIDTH	14.0 TO 45.0 FEET



PLAN

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FIGURE 2

FILE: TERRACES/SECBB

EXPERT SYSTEM PROGRAMS FOR GEOTECHNICAL FACTORS IN WETLAND ENGINEERING

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Three rule-based expert system (RBES) programs are being developed under a work unit of the Wetlands Research Program (WRP) at the USAE Waterways Experiment Station. This paper discusses the WRP geotechnical engineering expert systems. Implied in this paper is the possible application of similar RBES programs to other fields in wetlands restoration or creation work.

Soils-related engineering activities at a wetland restoration or creation project include the initial, and detailed, subsurface investigations and the soils handling operations. The significant engineering, and plant-growth, characteristics of the existing near-surface soils must be validly identified, described, and classified. If soils handling or earthworks are indicated for the project, then plans and specifications must be prepared for the excavation, transportation, and deposition of the soil. The deposition may be done in a disposal area, in a temporary storage area, or as fill in a dike or levee.

Persons who are knowledgeable and experienced in the various investigation, planning, and implementation aspects of a wetland project are not always readily available. Project- related knowledge is often not adequately transferred to associates and is usually lost on the possessor's retirement or position change. Inexperienced persons invariably need expert guidance, or even formal instruction, and experienced persons can always benefit from peer review.

A RBES computer program is a method by which the knowledge and experience of experts on specific subjects can be recorded, periodically reviewed, and made readily available in computer format (a) for the guidance and/or training of inexperienced personnel, and (b) as a form of peer review for experts. A RBES uses a knowledge base of expertly-derived rules for its solutions. The reasoning logic of the rules is in the form of IF - AND - THEN statements. Unlike algorithmic programs, the knowledge base of a RBES can incorporate judgment, experience, empirical rules of thumb, intuition, and other expertise as well as proven functional relationships and experimental evidence.

A RBES program sequence starts by asking pertinent questions, in the form of IF - AND - AND, about the topic. Ideally the user's response will be a selection from a menu of responses so that typing skill is not needed. The sequence of questions is determined by the responses to the previous questions. This,

effectively, assumes the form of a decision tree. All responses along a decision path are stored in temporary memory. After the RBES has accumulated all of the necessary background information for any of its rule structures, that rule fires and the appropriate guidance is presented on a screen in the form of a THEN response. If the path then leads to more information, additional questions are posed and additional guidance is presented. Most RBES programs allow the user to return to previous questions so that alternative routes can be explored.

In effect, a RBES is a technical report that has been placed into a computerized question-and-answer format. The sequence of questions is expert-guided for each specific task. A RBES is simpler, easier, and faster to use than a published report. Pages appear on the screen quickly rather than requiring hunting for the contents or index, then searching for the exact pages. The knowledge base is separate from the control program. Therefore, the content of the knowledge base can readily be modified or expanded as needed to accommodate additional expertise. This permits easily made modifications, or upgraded versions, of the program without the cost of republishing a paper report.

The WETSITE (WETland Geotechnical SITE Investigation Methods) program offers expert advice for use in the planning of a subsurface investigation for a wetland project. It provides guidance in the selection of subsurface investigation equipment and methods appropriate for the soil types that are known or assumed to be present at the site. The user selects the general soil type, known from project records or literature to be present in the near-surface at a specific location, from a menu. The RBES then displays all sampling devices that are suitable for that soil type. One of the sampling devices is selected, from the guidance menu, for further evaluation. The RBES then displays all of the various field and laboratory soil test methods that are appropriate for the selected soil type and sampling method. This process can be repeated for other suitable sampling devices. In this manner, the most suitable sampling and testing configuration for that location can be selected.

The GEOCLASS (GEOtechnical Soil CLASSification) program provides guidance in the field identification, description, and estimated classification of soil samples. Both the Unified Soil Classification System and the US Department of Agriculture Soil Taxonomy descriptions are developed. The user is guided, step-by-step, with field expedient tests that can be done quickly and without complex equipment. The objective is to develop consistent and valid field descriptions of the soils to be included in the boring or test pit logs.

The WETCONST (WETIands Earthwork CONSTruction) program offers expert guidance in the selection of appropriate equipment, materials, and methods for soils handling (earthwork) at a wetland

site. The suitability of various soil handling methods and equipment for use at a wetland site is determined by (a) the trafficability of the surface of the borrow area, the transport roadway, and the deposition site, (b) the quantity, location, and engineering characteristics of the soils to be moved, (c) the average grade of the transport roadway, and (d) the location and specifications for wetland site deposition.

Each of the RBES programs described above will contain an extensive HELP file that is accessible from all screens during the conduct of the programs. The HELP topics will include (a) a rationalization for all of the rules used in the specific RBES and (b) a number of additional reference topics that are intended to assist the user to understand the reasoning behind the guidance given by the program. This is often the most important element of a RBES program. The size of a HELP topics file is limited only by the size of the computer's data storage capacity.

SESSION ID1

IDENTIFICATION AND DELINEATION I
Ellis J. Clairain Jr., Chair

DELINEATION OF HYDROLOGICALLY ALTERED COASTAL WETLANDS: A CASE STUDY

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Introduction/Purpose of Investigation

The subject site is a 17 hectare (42 acre) parcel lying at the landward edge of a large, coastal lowlands complex in Orange County, California. These lowlands were historically a shallow lagoon and tidally influenced wetlands system. Over 100 years of natural and man-induced events have resulted in significant hydrologic alterations to the lowlands. Although hydrophytic vegetation (e.g., Salicornia, Frankenia) dominates much of the site and soils remain strongly redoximorphic, rainfall is currently the only hydrologic input. Two previous comprehensive delineations were conducted on the site; results ranged from 2.2 to 8.4 hectares (5.5 to 20.8 acres) of wetlands. The previous investigations established that rainfall causes significant rises in groundwater elevations (Bilhorn, 1986). The purpose of this new delineation was to determine if rainfall alone was sufficient to drive wetland hydrology.

Methodology

A comprehensive wetland delineation (Environmental Laboratory, 1987) was conducted beginning in 1992. Twelve pairs of piezometers were installed along transects across the site and monitored over three rainfall seasons (28 months); each pair included a shallow well, 0.5 m (1.5') deep, and a deep well, around 1.8 m (6.0') deep. Rainfall data from 1927 to 1994 were obtained from a gage located two miles southeast of the site. Forty-scale topographic maps (0.15 m [0.5'] contour interval) were obtained. Finally, groundwater data obtained from a well monitored during previous studies (Bilhorn, 1986, 1987) were examined; these data covered the years 1981 through 1983 and 1986-87.

Results and Analysis

Rainfall during the study (including the year prior) ranged

Figure 1
Precipitation v Groundwater Elevation

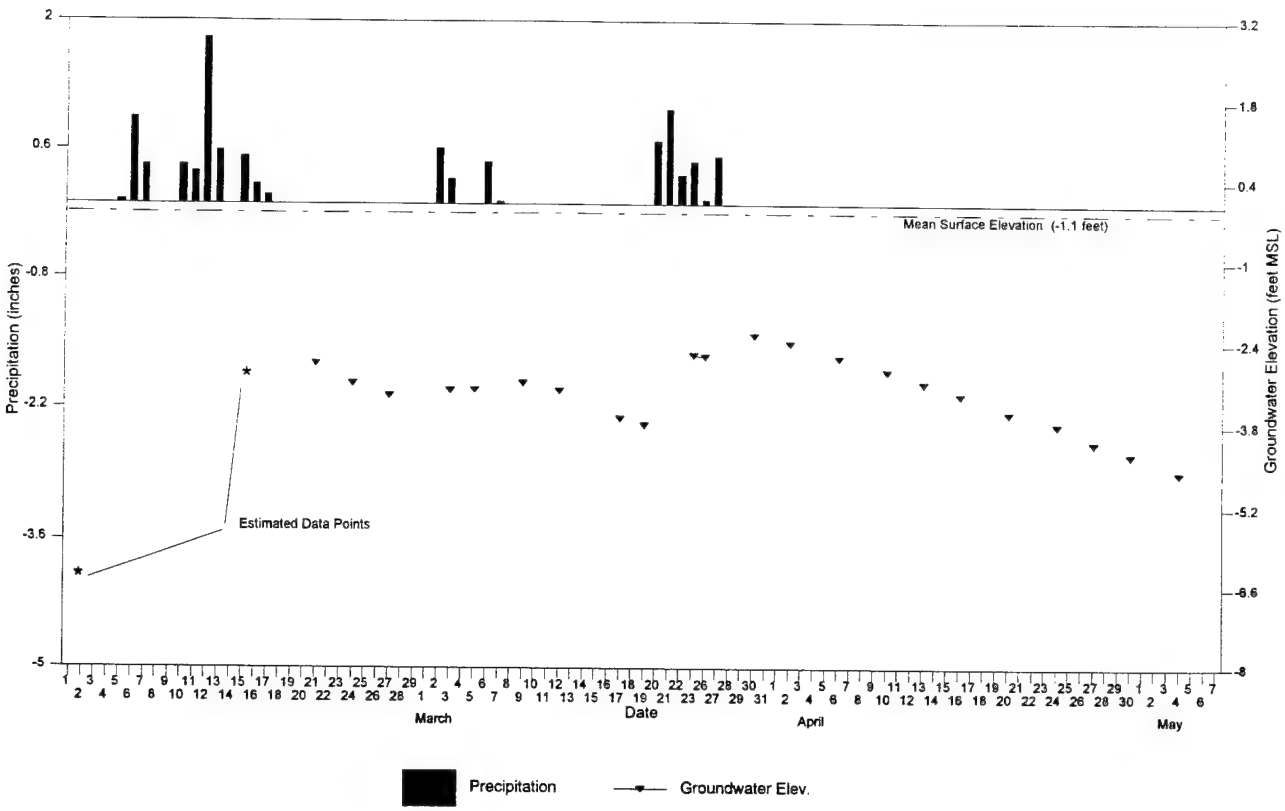

Table A - Duration of Surface Saturation - 1992

Well	Elevation	Maximum Groundwater Elevation	Max. Groundwater Elev. Sustained for 18 Days	Consecutive Days with Water Table <= 30.5 cm (12") below Surface	Percent of Growing Season Soils Saturated to Surface
1-D	0.3 m/1.0'	-0.3 m/-1.1'	-0.5 m/-1.6'	0	0
2-D	-0.3 m/-1.0'	-0.8 m/-2.7'	-1.2 m/-3.8'	0	0
4-D	-0.6 m/-2.0'	-0.8 m/-2.6'	-1.1 m/-3.7'	6	2
5-D	-0.4 m/-1.2'	-0.9 m/-3.0'	-1.0 m/-3.4'	0	0
6-D	-0.6 m/-1.8'	-0.8 m/-2.8'	-0.9 m/-3.1'	6	2
7-D	-0.5 m/-1.6'	-0.6 m/-2.1'	-0.9 m/-3.0'	12	3
8-D	-0.2 m/-0.8'	-0.8 m/-2.5'	-1.1 m/-3.7'	0	0
9-D	-0.49 m/-1.6'	-0.6 m/-1.9'	-0.8 m/-2.7'	15	4
10-D	-0.4 m/-1.3'	-1.0 m/-3.4'	-1.1 m/-3.6'	0	0
11-D	-0.3 m/-1.0'	-0.7 m/-2.2'	-1.0 m/-3.2'	0	0
12-D	-0.4 m/-1.2'	-0.5 m/-1.7'	-0.6 m/-2.1'	18	5
110A	-0.3 m/-1.1'	-0.7 m/-2.3'	-0.8 m/-2.7'	0	0

from 26.01 cm (10.24") to 47.65 cm (18.76"); median for the area is 25.83 cm (10.17"). The 1991-92 season, which included 34.77 cm (13.69") or 35 percent above the median was determined to represent a "normal" rainfall year. This year included three periods of intense storm events. Data showed that groundwater movements are directly related to storm intensity; it is the frequency and intensity of these storm events, rather than total rainfall, that ultimately determine whether the hydrology criterion is met in most years. To meet the Corps of Engineers hydrology criterion, an area must be saturated to the surface for a minimum of 5% of the growing season in most years; for coastal Orange County this represents about 18 days. LSA assumed saturation to the surface if groundwater reached within 30.5 cm (12") of the soil surface.

Conclusions

During the 1991-92 season, significant rises in groundwater followed intense storm events, as illustrated in Figure 1. Groundwater reached within 30.5 cm of the surface at three well locations; however, as illustrated in Table A, only one well showed groundwater within 30.5 cm of the surface for at least 18 days (well 12-D, 18 days). Because this was a wetter year than normal, based on total rainfall and intensity of rainfall events, it is reasonable to conclude that, on most of the subject site, saturation to the surface for 18 consecutive days does not occur during most years. Based on probability, only one year out of three would be expected to be wetter than the 1991-92 season; only during a wetter year could the hydrology criterion be met. LSA found a total of 2.04 hectares (5.04 acres) on the subject site that met Corps wetland criteria. This finding was confirmed by the Los Angeles District.

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IDENTIFYING AND DELINEATING ARID SALINE WETLANDS: FACTORS TO CONSIDER

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Abstract

As a national wetland identification and delineation methodology, the U.S. Army Corps of Engineers' 1987 Wetland Delineation Manual (Environmental Laboratory 1987) strongly emphasizes the need for professional judgment in applying the three parameter procedure. This need is especially important in dealing with areas characterized by complex ecological circumstances. Many areas, while not currently recognized as formal problem areas, are operationally difficult. One set of such hard-to-interpret areas are the saline nonwetland-riparian- wetland complexes which are relatively widespread in the arid environments of the American Great Basin and desert southwest. In an attempt to better describe the environmental gradients impacting these complexes, pertinent ecological principles, as well as, vegetation, hydrology, and soils considerations are presented. Ecosystem examples are given for the Coachella Valley of southern California, and for the Great Salt Lake area of Utah.

VEGETATION OF PLOWED AND UNPLOWED PLAYA LAKE WETLANDS IN SOUTHWEST KANSAS

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Introduction

Playa lakes are shallow, circular basins within the High Plains formed by wind during the Pleistocene Era. When rains occur, these playas pond water, allowing hydric soils and wetland vegetation to form. Highly variable climatic conditions along with extensive changes in surrounding hydrology on agricultural lands contribute to alternating wet and dry cycles within the playas. As a result, the vegetative mixture of the playas can change drastically from one season to another.

A study was conducted to determine the wetland vegetation status of selected plowed and unplowed playa lakes using the U.S. Army Corps of Engineers (Corps) <u>Wetlands Delineation Manual</u>

(Environmental Laboratory, 1987) definition of wetland vegetation. Although comparisons between the sites are made in this study, the findings are considered to be preliminary due to the wide range of climatic conditions possible in western Kansas and the limited number of sampling years.

Study Area and Methods

The playa lakes studied were located in Meade County, Kansas, in the southwestern part of the state. Average annual rainfall in this area is 21 inches. Two of the five unplowed playa lakes (Plains and Bull Lake) were sampled a total of four times: June 1993, September 1993, June 1994, and September 1994. The other three (Dead Cow, Oklahoma View, and Sand Creek) were sampled two times, in June and September 1994. Plowed playas have been sampled once, in July 1994. The Soil Conservation Service (SCS) maps all of the playas sampled as having hydric soils (United States Department of Agriculture, Soil Conservation Service, 1977).

Data from point sampling was used to analyze results from sampling trials. Due to the varying sizes of the playas, the number of points ranged from 40 to 60. In addition, the predominance of perennial versus annual species was analyzed. Species were identified using the reference Flora of the Great Plains (Great Plains Flora Association, 1991).

Point sampling data was grouped into one of five basic wetland categories as defined in the 1987 Wetlands Delineation Manual and listed in the National List of Plant Species that Occur in Wetlands (Reed, 1988):

1. Obligate Wetland Plants (OBL) almost always occur (>99%) in wetlands.

2. Facultative Wetland Plants (FACW) usually occur in wetlands (67% to 99%).

3. Facultative Plants (FAC) are equally found in wetland and upland areas (33% to 67%).

4. Facultative Upland Plants (FACU) usually occur in upland areas (67% to 99%).

5. Obligate Upland Plants (UPL) are almost always (>99%) found in upland areas.

Each species was given a numerical wetland value of 1 to 5 based on the category it fell into: OBL = 1, FACW = 2, FAC = 3, FACU = 4, UPL = 5. The sum of these wetland values was then divided by the number of points sampled. Playas with more than 50 percent of their species cover having an average wetland category number of less than 3.0 were indicative of wetlands.

Results

Table 1 illustrates the predominance of hydrophytic plant species within the unplowed playas. This table shows that among the unplowed playas, Plains, Bull Lake, and Dead Cow Playas all had wetland values of less than 3.0, while Sand Creek and Oklahoma View Playas had wetland values of 3.0 or higher. Table 2 shows the average wetland values for the plowed playas. Fourteen of the 27 plowed playas had wetland values of 3.0 or less.

The unplowed playas tended to be dominated by perennials. The predominant species in Plains, Bull Lake, and Dead Cow Playas were two spikerush species, <u>Eleocharis machrostachya</u> and <u>E. acicularis</u>, which are wetland obligate species.

In the plowed playas, annual vegetation dominated. Barnyard grass (<u>Echinochloa crusgalli</u>) and pink smartweed (<u>Polygonum bicorne</u>), both annuals, were dominant in 19 of the 27 plowed playas. The perennial bur ragweed (<u>Ambrosia grayi</u>) was common among both plowed and unplowed playas.

Conclusions

During the sampling periods, unplowed and plowed playas are dominated by hydrophytic vegetation, thereby appearing to meet the Corps definition of a wetland. Because of the unpredictable climate of southwest Kansas, it is still unclear as to whether they should be classified as wetlands.

The study also identified that plowed playas are dominated by annual vegetation, whereas unplowed playas are dominated by perennial vegetation. Agricultural production on the plowed playas causes regular disturbance of the land, therefore promoting the growth of annual, weedy species in these areas.

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TABLE 1
AVERAGE WETLAND VALUES FOR UNPLOWED PLAYAS

Location	June 1993	June 1994	September 1993	September 1994
Bull Lake Playa	2.00	2.10	1.90	1.20
Dead Cow Playa		2.00		1.90
Oklahoma View Playa		2.70		3.10
Plains Playa	2.20	1.90	2.20	2.60
Sand Creek Playa		4.10		3.60

TABLE 2
AVERAGE WETLAND VALUES FOR PLOWED PLAYAS

Location	Average Wetland Value	Location	Average Wetland Value
Playa 1	3.56	Playa 15	3.72
Playa 2	3.56	Playa 16	2.84
Playa 3	3.28	Playa 17	3.54
Playa 4	2.40	Playa 18	3.18
Playa 5	3.00	Playa 19	3.30
Playa 6	3.56	Playa 20	2.90
Playa 7	3.66	Playa 21	3.00
Playa 8	1.12	Playa 22	2.22
Playa 9	3.26	Playa 23	2.08
Playa 10	2.06	Playa 24	4.22
Playa 11	3.10	Playa 25	2.16
Playa 12	2.62	Playa 26	2.90
Playa 13	3.26	Playa 27	2.76
Playa 14	2.36		

MISSISSIPPI PINE SAVANNAHS, PINE FLATWOODS, AND FORESTED BAYHEADS: WETLAND DELINEATION, EVALUATION, AND MITIGATION CONSIDERATIONS

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Abstract

Although the pine savannahs and pine flatwoods of coastal Mississippi are vegetatively similar to the pine savannahs and flatwoods of Florida and the Atlantic Coastal Plain, there are significant soils differences. The savannahs and flatwoods of Mississippi generally occur on Ultisols (specifically Paleaquults, Aquic Paleudults, and Plinthaquic Paleudults), while the Florida and Atlantic Coast savannahs and flatwoods generally occur on Spodosols. Mississippi pine savannahs and flatwoods develop in response to three groundwater hydrologic sources: apparent water tables; perched water tables; and, short duration episaturation conditions. All three water sources apparently produce soil redoximorphic conditions and typically support similar plant communities, but they do not all necessarily constitute wetland hydrology. In an attempt to provide practical field guidance for wetland delineation, evaluation, and mitigation in these savannah, flatwoods, and in forested bayhead habitats, plant community ecology, hydrology, and soils information have been assimilated and interpreted from USDA Natural Resources Conservation Service data sources, published literature, and field experience in the area.

SESSION CP1

CRITICAL PROCESSES: WETLAND PROCESSES
Jack E. Davis, PE, Chair

REMOVAL OF POLLUTANTS BY WETLANDS

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Constructed and natural wetlands can function as effective treatment systems for removing water pollutants. Various processes, such as settling and sediment accretion, nitrification and denitrification, biodegradation, hydrolysis, volatilization, and photolysis, transform and remove pollutants. Methods are needed to predict the amount of pollutant material removed when evaluating wetland functions or when designing constructed wetlands for water quality improvement.

The amount of material removed from receiving water can be quantitatively expressed in terms of the removal efficiency (RE), where RE is the percentage of influent trapped or removed by the wetland. Thus, RE = 100% denotes total removal of a pollutant. An objective of this work was to develop a relatively simple, easy-to-use method for estimating RE. Thus, an analytical, screening-level model was formulated for this purpose.

The primary assumption made with the analytical model to achieve simplicity is that the wetland is at steady-state (i.e., flow and concentrations are constant in time). Although wetlands may not be at steady-state, steady-state analyses are useful for evaluating long-term, average conditions. Mean annual input conditions (e.g., flows, depth, etc.) are consistent with this assumption.

Either of two conditions are assumed for spatial gradients in concentration: 1) fully mixed (no gradients); and 2) longitudinal gradients exist along the main flow axis (well mixed laterally and vertically, or plug flow). RE for these two conditions can be calculated from relationships involving only bulk removal rate and detention time, which is equal to the hydraulic residence time for fully mixed and plug flow conditions. The bulk removal rate depends on pollutant-specific processes and wetland ambient conditions, such as water temperature, depth, and flow velocity. Thus, obtaining a representative K value can be

problematic. The approach here was to focus on the dominant long-term removal mechanisms, making use of literature values or mathematical formulations for those mechanisms when possible. The model contains algorithms for total suspended solids (TSS), total coliform bacteria (TCB), biochemical oxygen demand (BOD), total nitrogen (TN), total phosphorus (TP), and contaminants (e.g., organic chemicals and trace metals). Details of the removal rate formulations for each water quality constituent are described by Dortch and Gerald (1994).

The analytical model was tested against available field observations from the literature and from the Cache River wetland, a major study site of the Corps of Engineers Wetlands Research Program. Flows and concentrations observed at the upstream and downstream boundaries of the Cache River (i.e., Patterson and Cotton Plant gages, respectively) were used to integrate mass fluxes for estimating long-term RE values for TSS, TN, and TP. Observed and predicted RE values for the Cache River are summarized as follows:

Constituent	Observed RE, %	Predicted RE, %
TSS	29.5	25.9
TN	21.4	18.1
TP	3.0	3.1

The Cache River wetland effectively removes TSS and TN relative to TP. Higher RE values for TN are reasonable considering that denitrification in benthic sediments provides a significant removal pathway indefinitely. The low TP removal efficiency is related to the saturated conditions of the benthic sediments, i.e., the sediments have a low capacity to accept and retain additional phosphorus. Net phosphorus removal for an established wetland, such as the Cache River, is controlled by sediment burial, rather than through net settling from the water column as with a new wetland. The burial rate is much smaller than the net settling rate.

The steady-state analytical model provides a relatively simple method for estimating long-term, average removal efficiencies for pollutants in wetlands. The model also provides insights into why older wetlands remove little phosphorus while effectively removing other pollutants.

Acknowledgments

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BIRD COMMUNITIES IN RELATION TO FLOODPLAIN FOREST ZONES ALONG THE CACHE RIVER, ARKANSAS

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During spring of 1988 and winter of 1988-89, we sampled songbird populations and habitat characteristics along two belt transacts extending across the broad, forested floodplain of the Cache River, Arkansas, USA. Objectives were to compare avian abundance and species richness among floodplain forest zones, and to investigate bird species distributions in relation to the wetness gradient. Forest zones differed in structure, flooding regime, and use by birds. The tupelo/baldcypress zone, in particular, provided habitat unlike that in the higher oak-dominated zones, and supported a number of bird species that were much less abundant elsewhere. Distributions of chimney swifts, prothonotary warblers, and great crested flycatchers were skewed toward wetter sites, whereas summer tanagers, red-eyed vireos, and others were skewed toward drier sites. To maintain bird diversity in bottomland hardwood wetlands, it is important to maintain intact systems including all elevational forest zones.

DESIGNING WETLANDS FOR SPECIES RICHNESS: MACROINVERTEBRATE REQUIREMENTS

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Introduction

The coal producing region of the Appalachian Mountains has been identified as an area of increasing wetland acreage, a direct result of strip mining (Klimstra and Nawrot 1985). Historic surface mining techniques often created basins that led to wetland formation. Current mine reclamation practices strive to eliminate all standing water. However, wetland construction as a part of reclamation may provide ecological services, including wildlife habitat provision, erosion control and sediment retention, and water storage.

The focus of the research presented is macroinvertebrates inhabiting accidental wetlands on relic surface mine benches. These organisms play an integral role in the ecology and function of wetlands (Krieger 1992 and Murkin and Wrubleski 1988) and are a significant component of food webs, forming the link between the primary production/detrital resources and higher order consumers (Murkin and Wrubleski 1988). Macroinvertebrates affect the nutrient pool of the wetland ecosystem and may regulate nutrient movements through translocation and transformation of nutrients (Krieger 1992 and Murkin and Wrubleski 1988). This research seeks to determine structural characteristics of macroinvertebrate communities in accidental wetlands.

Methods

Macroinvertebrate surveys were conducted at the Powell River Project (PRP) Land Use Research Area in Wise County, VA, on nine accidental wetlands. The sites were sampled four times: July 1993, September 1993, March 1994, and May 1994. Three sweeps were taken per wetland per sample period using a D-frame net within a 0.25 m^2 area. The macroinvertebrate surveys included measurement of pH, temperature and water depth. Water chemistry parameters measured included conductivity; alkalinity; and iron, manganese, and sulfate concentration. Pearson's R correlation was used to identify relationships between taxa richness and the physical and chemical parameters of the sites.

Results and Discussion

The PRP sites have macroinvertebrate richness comparable to other mined areas (Barnes 1983, Fowler et al. 1985). Overall, the sites provide adequate habitat for colonization. However, water quality problems exist (e.g., iron and sulfate concentration), which may have reduced species richness in some wetlands. Correlations between macroinvertebrate richness and wetland physical and chemical parameters suggest that conductivity, iron

concentration, maximum depth, and hydrologic fluctuation influence the macroinvertebrate community (Table 1).

Table 1 Correlation coefficients (Pearson's R) and P-values for selected wetland parameters and taxa richness of surface mine accidental wetlands, Wise County, VA.

Parameter	Pearson's R	P-Value
Depth	-0.63	0.03
Fluctuation[1]	0.70	0.01
pH	0.41	0.18
Fe	-0.55	0.06
Mn	-0.35	0.27
SO_4	-0.47	0.13
Conductivity	-0.70	0.01
Alkalinity	0.05	0.88

[1] Fluctuation measured as standard deviation of mean site water level

The findings of this study can aid future development of wetlands for wildlife habitat on surface mine land. First, poor water quality adversely affects the macroinvertebrate community, suggesting that treatment wetlands may serve limited habitat functions. Second, depth is inversely related to taxa richness; therefore, richness would be increased in shallow areas of a depth <1-2 meters. Shallow depths are also more practical and favored by industry and regulatory personnel. Third, hydrologic fluctuation is positively correlated with richness, so the bottom slope should be gradual to maximize the area of transitional habitat.

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THE HYDROLOGY OF LONGLEAF PINE SAVANNAH WETLANDS IN LOUISIANA

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Less than 10% of intact longleaf pine savannahs remain in southeastern Louisiana (Louisiana Natural Heritage Program, 1990). Both the basic hydrology and hydrologic alterations caused by prescribed burning in longleaf pine savannahs are poorly understood. High soil moisture status and frequent fire are vital for maintenance of rich, viable pine flatwood savannahs (Louisiana Natural Heritage Prouram, 1990). Our objectives are to quantify the hydrologic budget and detemiine the effect of prescribed burning on the hydrology of Lake Ramsay Wildlife Management Area (WMA).

Transects were established along elevational gradients in the Lake Ramsay WMA. Permanent plots were established in hydric, transitional, and nonhydric soils along each transect. At each plot, replicated platinum redox electrodes and tensiometers were installed at 15- and 30-cm depths in the soil. A set of nested piezometers were installed at 30- 60- and 90-cm depths. On-site precipitation was measured usina rain gauges. Redox potential, water-table depth, soil moisture content, and precipitation were measured monthly from October 1993 through October 1994. Actual and potential evapotranspiration (ET) were calculated daily during

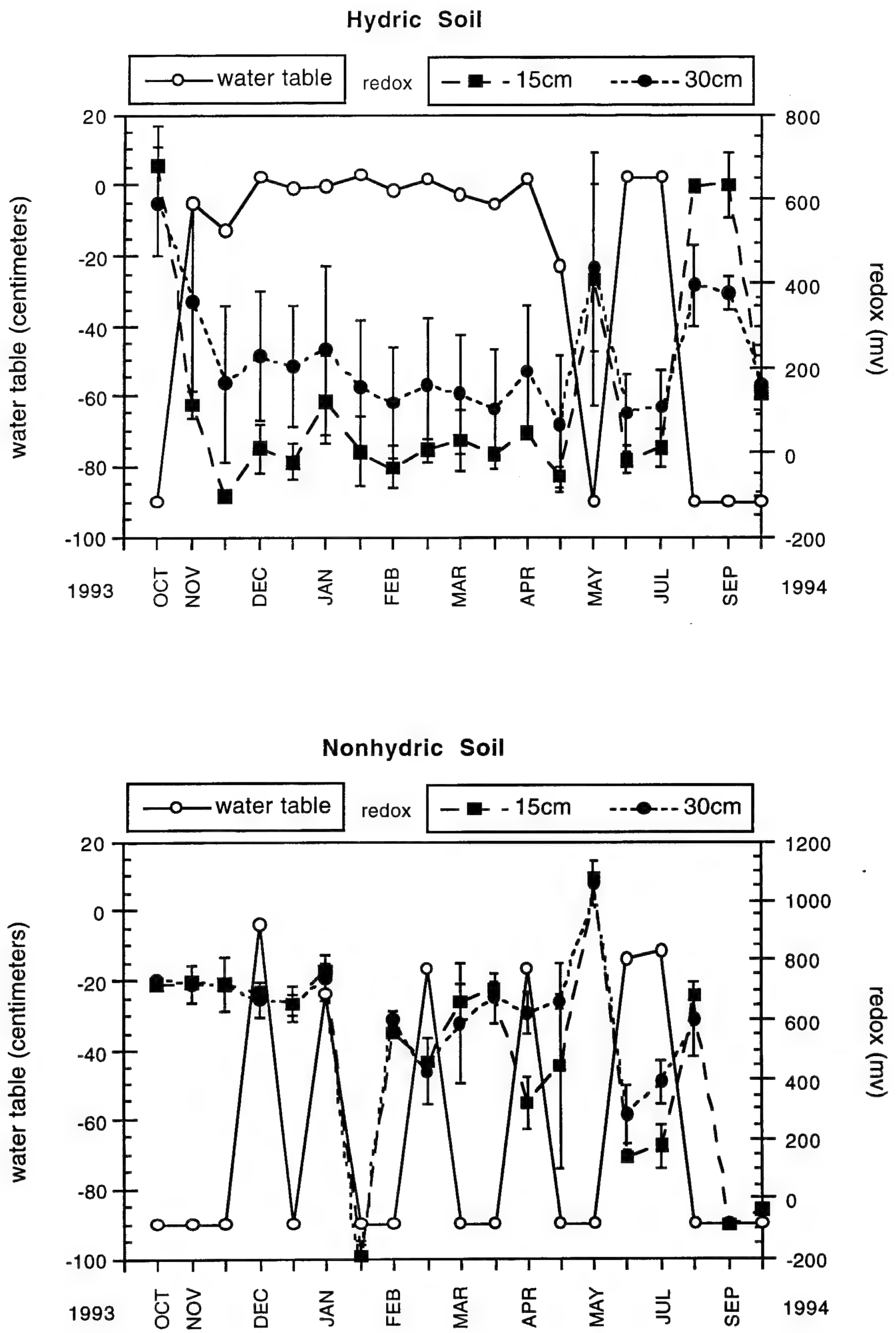

Figure 1. Water table and redox potential for hydric and nonhydric soils at Lake Ramsay Wildlife Management Area

the sampling period and totaled for each month using Covington weather station data with the Thomthwaite model. Representative soil profiles were described and sampled for the soil types found in the study area. To determine the effect of prescribed burning on hydrology, burned sites were paired with unburned sites with similar original in sitii conditions at approximately the same elevation and soil type (hydric or nonhydric). Water level was measured periodically beginning one day after burning, followed by weekly measurements for a month after burning, and biweekly measurements during the second month.

Water-table depth, degree of saturation and degree of reduction were strongly related to hydric soil status. At the hydric site (Fig. 1), water level remained high and soils were reduced and saturated from November until April and in June and July. Ferrous iron, a redoximorphic feature was also present. Redox potential rose with decreases in water level in May, and from August through October. At the nonhydric site (Fig. 1), water level was generally low with a few periods of water within the top 30 cm. The soil was more oxidized and less saturated than at the hydric site. Ferrous iron was not present. Wetter, more saturated conditions occurred in winter and spring with drier, unsaturated conditions in summer and fall in both soils. Precipitation measured at the sites varied monthly, with high rainfall occurring in April, June, September and November, 1994. The rainfall events for April and June resulted in high water tables and low redox potentials for both soils (Fig. 1).

Yearly potential evapotranspiration totaled 108 cm and rainfall totaled 123 cm yielding a net surplus of 15 cm. The hydrologic budget is dominated by precipitation inflows and losses through evapotranspiration. As expected, prescribed burning reduced evapotranspiration resulting in higher water levels at burned sites compared with unburned sites of approximately the same elevation.

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SMALL MAMMALS, REPTILES, AND AMPHIBIANS IN BOTTOMLAND HARDWOODS OF THE CACHE RIVER, ARKANSAS

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Effective management of wetland systems requires knowledge of the wildlife functions of these habitats. Studies are needed that document the associations between vertebrate populations and those wetland features most often examined and monitored by natural resource regulators and managers. Amphibian, reptile, and small mammal populations in the lower Cache River basin, Arkansas, were studied with relation to hydrologic gradients, and the associated vegetation and habitat structure. Species composition, abundances, and distributions were documented under conditions of varying flooding conditions. Circular 0.04 ha plots along two 1-mile transects were sampled in three seasons (excluding winter) in two years (1988 and 1990). Faunal and vegetative data were analyzed both to provide summary statistics concerning species composition and numbers of individuals captured and to relate associations among the variables measured. Statistical analyses that explored the relationships between faunal, habitat structure, and topographic gradient characteristics included a number of multivariate techniques.

Several habitat structure variables were related to factors associated with the hydrologic gradient. Species richness among a number of vegetative forms increased with increasing elevation and distance from the river. Woody cover near the ground and in the upper canopy increased with elevation on Transect A as did woody cover in the mid-canopy on Transect C. Leaf litter was more abundant with increasing elevation and distance from the river. The density and basal area of hard mast trees was positively correlated with elevation and distance from the river, whereas these variables for soft mast trees were inversely related to elevation and proximity to the river. Six herptofaunal species comprised the majority of captures. Statistical tests for correlations with elevation and distance from the river indicated that the distributions of a number of species were highly related to these variables. The distribution of the marbled salamander (<u>Ambystoma opacum</u>) was correlated with plot elevation, and the number of amphibian and reptile species and southern leopard frogs (<u>Rana sphenocephala</u>) captured was inversely related to distance from the river. The cotton mouse (<u>Peromyscus gossypinus</u>) and white-footed mouse (<u>P. leucopus</u>) were the predominant small mammal captures for both years on both transects. White-footed mice were caught in greater numbers on dry plots on Transect A, whereas no such trend existed for cotton mice. In fact, cotton mice were captured in greater numbers on Transect C, where overall conditions were wetter. All observed associations do not necessarily reflect causal relationships, but they do provide some insight concerning the function of various habitat features.

SESSION SM1

STEWARDSHIP AND MANAGEMENT: MAPPING AND INVENTORY

Porter Reed Jr., Chair

THE NATIONAL WETLAND INVENTORY

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Abstract

The National Wetlands Inventory (NWI) of the US Fish and Wildlife Service is mandated by Congress to complete wetlands mapping of the conterminous United States by 1998 and to produce a wetlands digital database for all 50 states by 2004. This database will constitute the wetlands layer of the National Spatial Data Infrastructure. The NWI has completed mapping 85 percent of the lower 48 states, all of Hawaii, and 28 percent of Alaska. Digital wetlands data (location and classification) are available for 20 percent (14,000 quads) of the lower 48 states, all of Hawaii (140 quads) and 3.5 percent (100 quads) of Alaska. These data are available in DLG format over the Internet at no cost to the public. The NWI maintains two sites to serve NWI data: Anonymous ftp to serve DLG files, indexes, software, and metadata, and World Wide Web to access mapping status.

RESOURCE CATEGORIZATION OF NEBRASKA'S EASTERN SALINE WETLANDS

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Eastern Nebraska saline wetlands are regionally unique,

located in floodplain swales and depressions within the Salt Creek and Rock Creek watersheds in Lancaster and southern Saunders counties of Nebraska. Water regimes are temporarily- flooded and seasonally-flooded on saline mineral soils. Water sources are a combination of discharge from the aquifer of the Dakota sandstone formation, precipitation, and overbank flooding. Salts are concentrated in the soil during the dry periods. Wetland vegetation is characterized by halophytes including spearscale (Atriplex subspicata), inland saltgrass (Distichlis spicata var. stricta), saltwort (Salicornia rubra), prairie bulrush (Scirpus maritimus var. paludosus), and sea blite (Suaeda depressa). Saline wetlands are considered the most threatened complex in Nebraska.

An updated inventory of these wetlands and a technical assessment of their values were conducted from September 1992 through September 1993. The goal of this interagency initiative was to produce maps showing the locations of wetlands occurring on saline soils, and assign category designations for future application to proactive wetland initiatives. A Nebraska Game and Parks Commission saline wetland survey and National Wetland Inventory mapping served as the principal data sources in map production. Review of existing data and field evaluations were conducted to determine category designations.

Criteria for categorization included the occurrence of the rare endemic Salt Creek tiger beetle (Cicindela nevadica var. lincolniana), presence of rare or restricted halophytes, historical significance, occurrence of halophytic associations, degree of degradation, and restoration potential. These criteria were then incorporated into a dichotomous key to facilitate a standardized wetland categorization procedure.

Four wetland categories were identified, corresponding to the relative quality of the remaining resources. Results were summarized in a database and used for geographic information system-based mapping. A total of 276 individual wetlands possessing saline characteristics was identified. Over 70 percent of these sites had sufficient data for category designation. A total of 5,644.1 acres of wetlands and deepwater habitats was identified within the study area. These data are currently being applied to private mitigation banking initiatives and local zoning applications.

MAPPING THE WETLANDS OF COASTAL NORTH CAROLINA

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The North Carolina Division of Coastal Management (DCM) is developing a coastal area wetlands conservation plan which relies on adequate knowledge of the location and extent of wetlands by watershed in coastal NC. After reviewing existing data, DCM determined that none of the data could be used exclusively as an inventory for the conservation plan. Therefore, DCM has developed methods using geographic information systems (GIS) and existing spatial data to accommodate a limited time schedule and large land area (Figure 1). Three primary spatial data layers provide information that are assembled into the DCM wetlands map. These layers are the National Wetlands Inventory (NWI), county soils (DSL), and classified land use/land cover from TM satellite imagery. The NWI and DSL data are 1:24,000 scale,, vector data. The imagery is 30 meter resolution, filtered and unfiltered, raster data. Extracting the most relevant information from each of these layers allows DCM to produce the best information about the location and extent of coastal area wetlands available today.

DCM's classification scheme is based on both vegetative cover and hydrogeomorphic character (see Brinson 1993). Wetland classes currently recognized by DCM are outlined in Table 1. In addition, modifiers may be applied to any of these categories indicating that they have been drained or cleared of vegetation. An automated Arc/Info model considers the NWI classification (see Cowardin et al. 1979) and the imagery classification (see Khorram et al. 1992) in assigning a wetland type to each polygon. Soil types are used to determine whether or not marginal areas are considered to be wetlands, including managed pine areas. Once the automation is complete, an interactive session allows the user to assign wetlands to classes specific to their position in the landscape, A hydrographic data layer is used in addition to the layers mentioned previously to more easily interpret the landscape position and hydrogeomorphology (HGM) of the wetlands. For example, a temporarily flooded, hardwood area may be classified as bottomland hardwood or hardwood flat, depending on its location: adjacent to

Salt/Brackish Marsh
Estuarine Shrub-Scrub
Estuarine Forest
Maritime Forest
Freshwater Marsh
Pocosin
Bottomland Hardwood
Swamp Forest
Headwater Swamp
Hardwood Flat
Pine Flat
Managed Pineland
Impacted

Table 1 Wetland classes currently recognized by DCM.

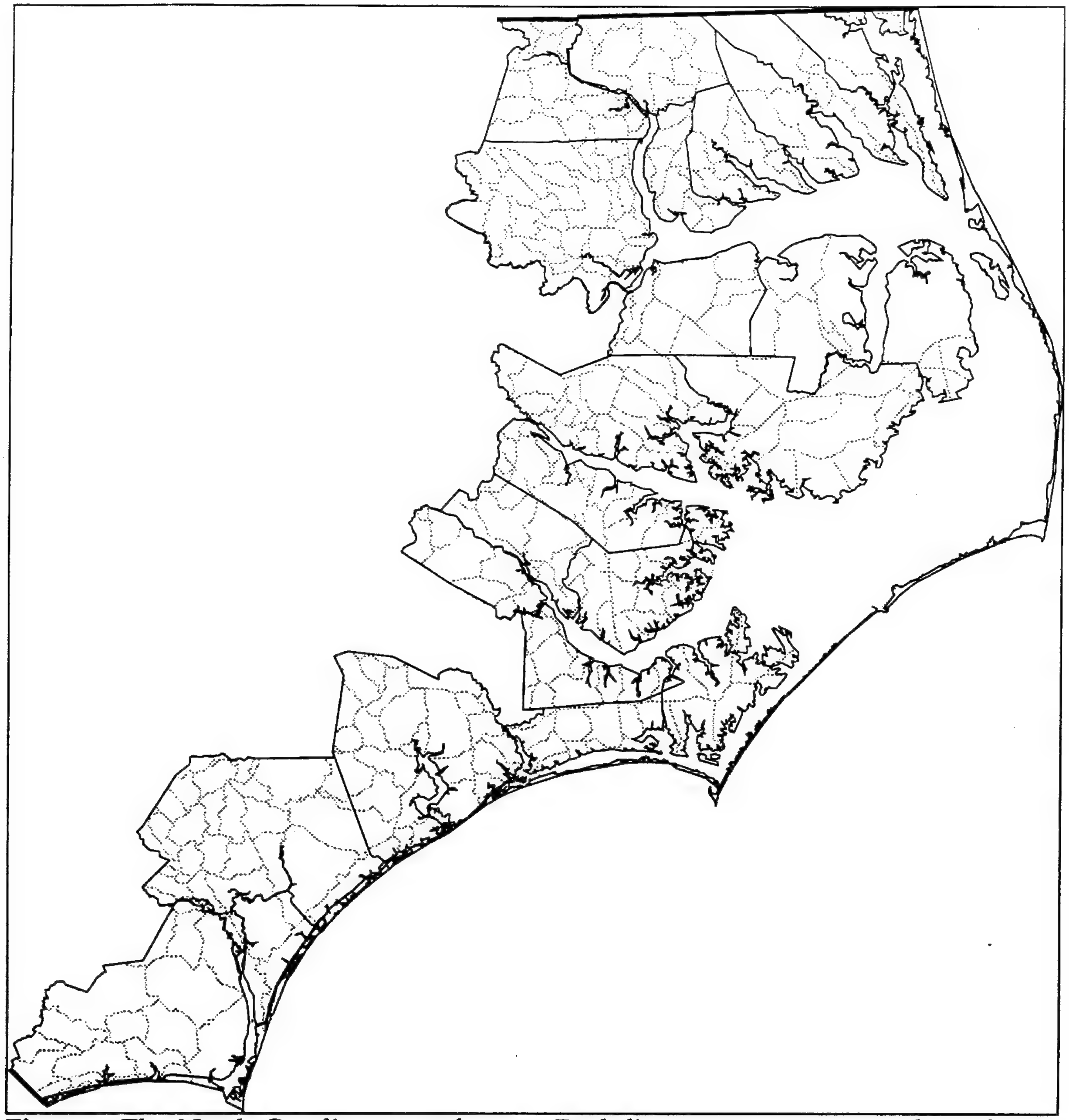

Figure 1 The North Carolina coastal area. Dark lines represent county boundaries. Dotted lines represent small watershed boundaries.

a stream or within an interfluvial divide, respectively. Finally, each wetland is assigned to an HGM class of riverine, flat/depressional or headwater. (Salt marshes are not assigned to an HGM class because they are statutorily protected in NC.)

As humankind continues to understand more about the role of wetlands in maintaining a healthy environment, the usefulness of

wetlands locational data continues to grow in importance. Such spatial data can assist county planners in guiding growth away from environmentally sensitive areas. Landowners can view a map and realize that wetlands do or do not exist on a large area of land. Economic development interests can use this information to guide development to areas devoid of wetlands, thus avoiding the wetlands permitting process. These maps serve as the base data for other projects, including the assessment of ecological function and the identification and prioritization of potential restoration sites. These data have innumerable other uses and will be made available to local governments in paper or digital form as they are completed.

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ACTIVE AND PASSIVE MICROWAVE REMOTE SENSING TO IDENTIFY WETLAND REGIONS: DATA AND SIMULATIONS

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Identification, classification and delineation of wetland regions, as well as subsequent long-term monitoring, has become increasingly important in recent years. The level of regulatory enforcement and the varieties of wetlands under scrutiny has increased considerably. The need for methods for rapid, accurate and consistent monitoring of wetland regions has risen accordingly. Both passive and active microwave remote sensing show great potential for filling this need.

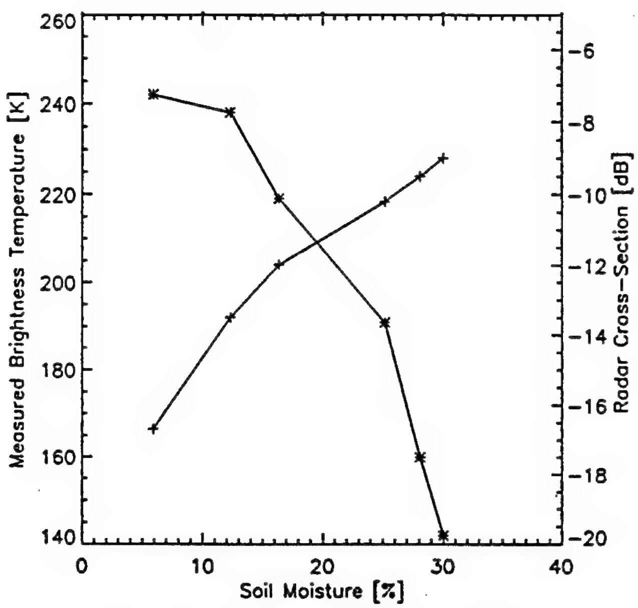

Fig. 1. Passive microwave measurements or brightness temperature (asterisks) at 1.5 GHz for a range of soil moisture values at a wetland site in Lincoln, NE. The crosses represent modeled radar cross-section estimates for the same surface moisture conditions.

Passive remote sensing (radiometry) has demonstrated marked success in soil wetness estimation in recent years. This is due to the direct relationship between received power which can be related to the surface emissivity and the soil dielectric constant which is a function of the soil water content. However, the weakness of passive sensing techniques is that the beamwidth, and thus the ground spatial resolution achieved, 'Is inversely proportional to the antenna size. To keep the hardware dimensions reasonable, one must usually be content with rather poor ground resolution.

Active remote sensing instruments are also sensitive to soil wetness, and are able to overcome the spatial resolution problem using signal processesing techniques. The difficulty with active sensing of soil wetness is that the radar return signal is also sensitive to surface roughness. This manifests itself as an identification ambiguity in wetland areas. Specifically, over dry soil the radar return is very small and increases rapidly with increasing water content. When a region becomes completely water covered, however, the radar return is dominated by the smooth surface specular reflection and for offnadir observations, the return power will decrease significantly. Thus, without additional information one cannot unambiguously distinguish between dry soil and water-logged surface.

The strengths and weaknesses of the two techniques are complementary, and lend themselves to a dual approach for accurate delineation of wetland boundaries.

In August of 1994, passive microwave data in the frequency range 1-2 GHz were collected at a wetland site in Lincoln, Nebraska. The surface conditions range in wetness from 5.9% to completely water covered (depth to 30 cm). The data are presented in Figure 1. Clearly, the radio-I metric brightness temperature (a measure of the received power) increases significantly with increasing water content. Overlayed on the figure are calculated radar backscatter estimates (a') for the same wetness values. As discussed above, the backscatter increases initially with wetness, and is then expected to drop off significantly over water.

As part of an ongoing research project, measurements will be made this spring at the same and additional sights concurrently with both an active and passive system to fully demonstrate this technique. The implication of such an approach for long term monitoring is that a dual system has the potential to accurately indicate (via an inversion algorithm) soil wetness at the spatial resolution achievable with an active sensor.

SESSION WP1

WATERSHED PLANNING
Ms. Laura Mazanti, Chair

A SPECIAL AREA MANAGEMENT PLAN FOR THE HACKENSACK MEADOWLANDS DISTRICT

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The Hackensack Meadowlands District (District) is a 32-square mile subsection of an important urban estuary, located 5 miles from New York City. Its wetlands, mud flats, and open waters provide critical habitat within the Atlantic Flyway. However, this region has endured centuries of environmental abuse and is currently under tremendous development pressure. Real estate prices are among the highest in the nation,

In 1969, the New Jersey Legislature created the District from portions of 14 municipalities. It also established the Hackensack Meadowlands Development Commission (HMDC) to protect the area's ecosystem, to foster its orderly economic development, and to provide solid waste disposal opportunities. These mandates were one of the first attempts at wetlands protection through land-use planning.

Subsequent passage of the Clean Water Act (CWA) and the Endangered Species Act, as well as creation of the New Jersey Department of Environmental Protection (NJDEP) resulted in inconsistencies between the approaches of the various regulatory agencies, stifling both economic development and much-needed environmental improvements within the District.

In 1988 the HMDC signed a Memorandum of Understanding with the US Environmental Protection Agency (EPA), the US Army Corps of Engineers (Corps), the NJDEP, and the National Oceanic and Atmospheric Administration to develop a Special Area Management Plan (SAMP) for the District. Its objectives were to provide consistency between the District's Master Plan and the CWA, to ensure no net loss of wetland values, and to improve regulatory efficiency within the District.

The Draft Environmental Impact Statement (EIS) for the SAMP is due for public release during the spring of 1995. The EPA and the Corps expect to sign the Record of Decision in the autumn,

1995.

The SAMP will feature a 1 billion dollar environmental improvement program, including a comprehensive 20-year wetlands management plan, mitigation bank(s), and the enhancement of 3,400 acres of degraded wetlands. Regulatory certainty, efficiency and equity will be improved through the consolidation of state and federal programs, establishment of an interagency mitigation advisory committee, and the adoption of financial programs to compensate owners of protected wetlands.

A wetlands indexing methodology was developed for the SAMP EIS to track gains and losses in wetlands functions, An analysis of out-of-District alternatives was also conducted, The completed EIS is expected to satisfy the "practicable alternatives test" required by CWA Section 404(b)(1) guidelines.

As a result, regulatory efficiency will be improved within designated areas through the issuance of a General Permit authorizing the placement of up to 15 acres of fill and an Abbreviated Permit Process for wetland disturbances greater than 15 acres. SAMP-consistent activities will receive a blanket Coastal Zone Consistency Determination and Section 401 Water Quality Certification. As a result, up to 10 billion dollars in economic growth will be expedited over a 20-year period,, while limiting wetland disturbances to 842 acres with limited wetland functions.

Over 4,100 acres of wetlands will benefit from increased protection through the requirement of a higher burden of proof for individual permits, inconsistency with the State's revised Coastal Zone Plan, purchase of development rights on selected properties, conservation easements and deed restrictions.

FRAMEWORK FOR WETLAND SYSTEMS MANAGEMENT

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The capacity of wetlands to provide specific functions is inextricably linked to the larger landscape in which it occurs. A framework for managing wetlands as subsystems of larger landscape systems has been developed which recognizes that wetlands are the product of interaction among atmospheric, geologic, hydrologic, and biologic materials and processes.

The framework provides guidance for formulating and implementing a comprehensive wetlands management program. The

management program has three phases: management plan formulation, database compilation, and management program implementation. The framework provides specific guidelines for assessing available fiscal and human resources, and locating and compiling existing data. It provides guidance in establishing priorities and goals for management plans. The framework also provides specific guidelines for implementing long-term management programs that are capable of evolving as the database and understanding of the landscape increase.

WETLANDS RESTORATION AS AN ELEMENT OF A MULTI-OBJECTIVE WATERSHED RESTORATION PROJECT

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The Lackawanna River Basin, located in northeastern Pennsylvania, has been a hub for anthracite mining activities, industrial development, and transportation for nearly 150 years. Much of the landscape and many of the current problems in the basin reflect the legacy of past resource exploitation.

The major water resources and environmental problems of the basin are the following:

1. Acid mine drainage

2. Wastewater discharges and combined sewer overflows

3. Environmental degradation to the river and wetlands caused by existing flood control projects, mined lands, floodplain encroachment, and an apathy and misunderstanding of the benefits and importance of the river and its adjacent wetlands

In response to these problems, the US Army Corps of Engineers, Baltimore District, in a partnership with the National Park Service and Lackawanna River Corridor Association, completed a reconnaissance study and developed a multi-objective, comprehensive river corridor greenway plan. The goals of the plan were to:

1. Alleviate existing water and environmental resource problems by relying on natural solutions such as constructed wetlands, stream

channel restoration, and replacement of the natural flood carrying capacity of the floodplain.

2. Develop a linear corridor system to connect various resources within the basin.

This paper will describe the multi-objective plan developed for the watershed, which included wetland creation to mitigate the loss of wetland areas and to treat acid mine drainage. It will discuss obstacles that have been encountered in obtaining funding and support for further design and implementation of the proposed solutions. Finally, it will highlight lessons learned in developing partnerships among federal, state, and local agencies and private organizations to combine resources, achieve common goals, and ensure successful implementation of a watershed restoration project.

WATERSHED-WIDE PLANNING FOR STORMWATER, PARKS, AND WETLANDS

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In response to the current whole watershed perspective for all policy and regulatory activities related to the Clean Water Act, an integrated watershed management plan was launched for a sensitive 970-acre watershed containing more than 100-acres of contiguous wetlands along its mainstem. Integrated water management objectives were developed from: hydrologic modeling for regional stormwater management; assessment of wetland enhancement/restoration opportunities; land-development analysis; and planning for a regional wetland reserve research park. The technical and public involvement process for development of objectives will be reviewed. Strategies for optimal implementation of multiple-use water resource management will be discussed.

Woolpert developed a diversified team of professionals to assess each element of this study while maintaining the vision of an integrated design to meet all stated objectives. The professional disciplines represented in the Cuppy-McClure team include hydrologic engineers, environmental planners, environmental scientists, landscape architects, a hydrogeologist, engineering technicians, and land surveyors. All local agencies and organizations with jurisdiction and interest in the Cuppy- McClure watershed were instilled through meetings and correspondence as partners in the efforts to craft an optimum solution to as many community needs as possible within the watershed.

The project started with an intensive collection and review of pertinent physical and administrative data. Other information was added from field surveys, agency contacts, and interviews. Physical characterization of the basin was used to prepare a hydrologic model of existing conditions within the watershed. Additional analysis included examination of projected land-use scenarios and initial program development for the wetland reserve/park. The hydrologic model was then modified to assess hydrologic response expected from projected future development.

The information developed from the watershed analysis described above was used to develop the integrated management objectives to meet the target needs. Design concepts for regional stormwater detention, park design, and wetland restoration were carefully merged on the landscape in the context of existing physical features. The goal was to design improved wetland management, improved water quality, and educational/recreational opportunities as parts of the same system. Each element was designed to complement the others while providing the overarching goal of integrated water management for multiple benefits.

A following phase will develop detailed design for the regional wetland reserve in the heart of the watershed including specifications for restoration of additional, associated wetland areas as an integral part of meeting overall resource management objectives.

WATER SUPPLY POTENTIAL AND ENVIRONMENTAL BENEFITS OF AN EVERGLADES BUFFER

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The South Florida Water Management District (District) is developing the Lower East Coast Regional Water Supply Plan to identify strategies for meeting urban, agricultural, and natural systems water demands through the year 2010. One concept under review is diversion to storage of excess surface waters discharged to tide. As currently proposed, an "Everglades Buffer" would be

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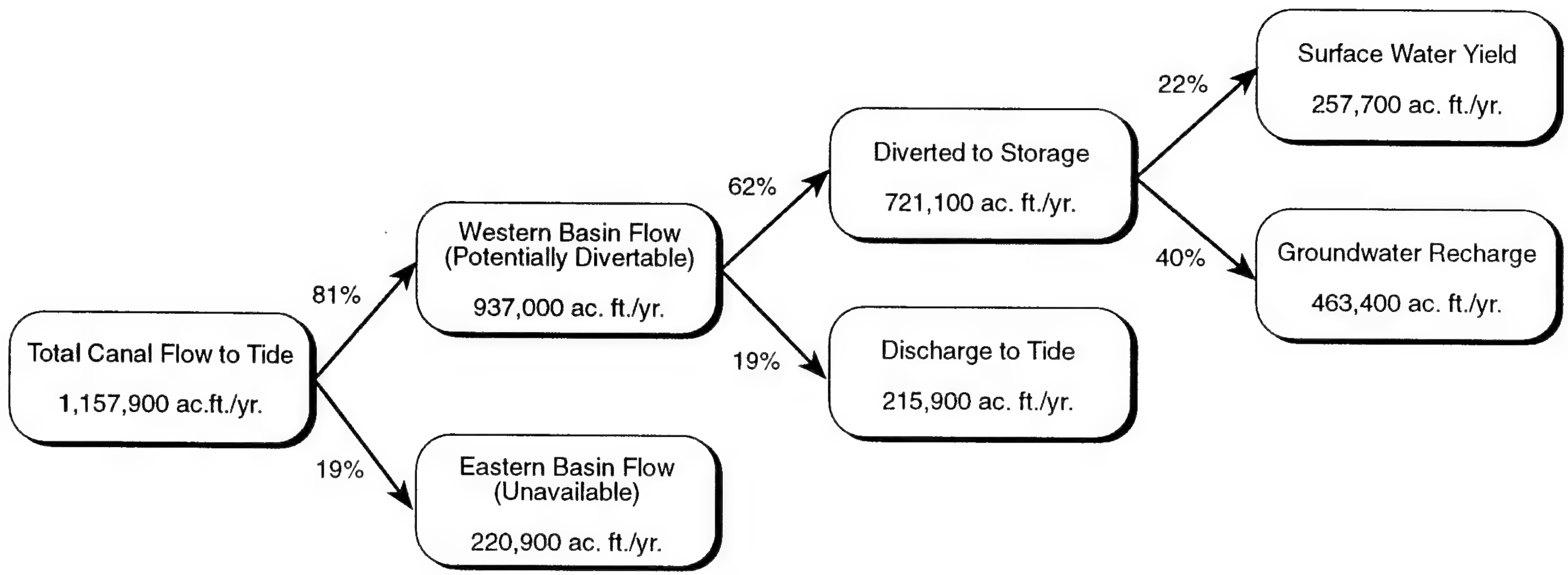

Note: Surface water yield = urban + natural systems
Groundwater recharge = direct groundwater recharge + seepage.

FIGURE 1.
Total Annual Flow Volumes.

constructed as a integrated system of above- ground reservoirs, wetland management units, and groundwater recharge basins located between the remaining Everglades and the urbanized areas to the east. A portion of the excess freshwater discharges would be backpumped to storage in the Buffer.

Studies conducted by CH2M HILL in partnership with the District included hydrologic analyses of surface flows potentially available for diversion to storage; GIS siting of the conceptual Buffer footprint; conceptual designs and cost estimation; water supply and seepage modeling; estimation of success at restoring targeted hydroperiods in wetland management units; and preliminary analysis of the potential water supply benefits realized by linking the Buffer with Aquifer Storage and Recovery (ASR) well systems.

The multiple benefits of this system would include the following:

1. Reduced seepage losses from the Everglades

2. Restoration of surface flows back to the Everglades from the LEC, with water quality enhancement capabilities, if required

3. Enhancement of short-hydroperiod wetland habitats

4. Increased recharge of the Biscayne Aquifer and associated wellfields

5. Reduce LEC water supply reliance on Lake Okeechobee

6. Protection of water supply wellfields

7. Protection of the remaining Everglades from urban encroachment

8. Creation of recreational and educational facilities

9. Inhibit exotic species invasion of the Everglades

For the eight drainage basins evaluated, just under 1.2 million ac-ft/yr are discharged to tide on an annual average basis. Of this total, 940,000 ac-ft/yr were identified as potentially divertable to storage (See Figure 1). Because of storage capacity limitations, the total estimated yield (surface water yield plus groundwater recharge) was about 721,000 ac- ft/yr. The other 200,000 ac-ft/yr could probably also be captured and used to meet future water supply demands through the use of ASR technology. The Buffer will be a key element of the LEC Regional Water Supply Plan and also was incorporated into five of the six US Army Corps of Engineers (COE) Central and South Florida (C&SF) Restudy Plans. More detailed feasibility analyses to be conducted under a District-COE partnership are under development.

BALANCING FLOOD PROTECTION AND HABITAT PRESERVATION IN THE MOJAVE RIVER

Lovert, Ekert, Stonestreet, and Diede

Regulatory and floodplain agencies typically disagree on alternatives, monitoring, and mitigation. To ensure plans integrate engineering and environmental concerns, a new Majave Rive strategy was implemented in Fall 1993. The Corps and San Bernardino County Flood Control District developed an interim plan conserving environmental resources while protecting life and property at immediate risk. Land uses and environmental variables were weighed heavily from the outset, along with hydraulic factors. The plan minimally cleared the upstream reach (urban), and selectively removed constrictions downstream (open space). It supplemented the 1987 permit applications, and was implemented in 1994 along with development of a similar long-term plan.

Success was achieved by involving the resource agencies and incorporating concerns during plan formulation. A mutual trust was generated, resulting in agreement to implement the plan while deferring mitigation to the long-term, using data gained from the interim. This paper discusses the hydraulic, environmental, and conflict resolution techniques used.

SESSION RE3

RESTORATION, PROTECTION, AND CREATION: FRESHWATER WETLAND CREATION AND RESTORATION IN SOUTH CAROLINA

Dr. Gary R. Wein, Chair

MONITORING INITIAL VEGETATION RESPONSES IN A MANIPULATED CAROLINA BAY WETLAND

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The impetus for this study on Carolina Bay restoration stems from the need for detailed information on the factors influencing freshwater wetland restoration. The project details the restoration treatments and initial vegetation monitoring plan for a drained Carolina Bay on the Savannah River site in South Carolina. The bay was drained in the mid 1940's for agricultural purposes and has subsequently developed non-wetland vegetation. We will attempt to describe herbaceous vegetation changes from pre-restoration treatments through the next two growing seasons after restoration manipulations. Manipulations involve restoring the original hydrology of the bay as well as subjecting portions of the bay to varying treatments of canopy and litter removal. The project will analyze vegetation response differences within and between the respective treatments. Seed bank data collected immediately after treatments will be compared to initial vegetation responses to determine the importance of in situ seed sources.

RESTORATION OF LOST LAKE, RECOVERY OF AN IMPACTED CAROLINA BAY

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Lost Lake is one of approximately 200 Carolina bays found on the Savannah River site (SRS), a US Department of Energy (DOE)

facility near Aiken, SC. Carolina bays are shallow isolated interstream wetlands found only on the Atlantic Coastal Plain and are characterized by sandy margins, fluctuating water levels, and an elliptical shape. Prior to establishment of the SRS in 1950, Lost Lake was ditched and drained for agricultural production. After 1950, the ditch filled and Lost Lake again began to function as a wetland. Until 1984, Lost Lake was contaminated by heavy metals, solvents, and cleaning fluids leaching from the M- Area settling basin at SRS. A closure plan for restoration was approved in 1987 and implemented in 1990 and 1991. The restoration was a cooperative effort led by DOE and included representatives from Westinghouse Savannah River Company, the USDA Soil Conservation Service, USDA Forest Service, and the University of Georgia Savannah River Ecology Laboratory. Extensive planning led to defined objectives, strategies, treatments, and monitoring programs allowing successful restoration of Lost Lake.

AMPHIBIAN AND REPTILE RECOLONIZATION OF LOST LAKE, A RESTORED CAROLINA BAY

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Introduction

Carolina bays are shallow wetland interstream depressions found only on the Atlantic Coastal Plain. Lost Lake, an 11.3-hectare Carolina bay, was drained for agricultural production before establishment of the Savannah River Site in 1950. Later it received overflow from a seepage basin containing a variety of chemicals, primarily solvents and heavy metals. In 1990, a plan was developed for the restoration of Lost Lake and restoration activities were complete by mid-1991. Lost Lake is the first known project designed for the restoration and recovery of a Carolina bay.

Methods

The bay was divided into eight soil treatment zones, and each of the eight zones was planted with eight species of native wetland plants. Recolonization of the bay by amphibians and reptiles is

Table 1. Amphibian and reptile species collected or observed at Lost Lake, Savannah River Site, South Carolina, May 1993 -January 1995.

Species		Number Collected
CLASS AMPHIBIA		
Order Caudata - Salamanders		
[2]*Ambystoma opacum* (marbled salamander)		23
[1,2]*Ambystoma talpoideum* (mole salamander)		1,619
[1,2]*Ambystoma tigrinum* (tiger salamander)		177
[1,2]*Notophthalmus viridescens* (eastern newt)		2,479
[2]*Plethodon glutinosus* (slimy salamander)		39
Order Anura - Frogs and Toads		
[1]*Acris gryllus* (southern cricket frog)		698
[2]*Bufo quercicus* (oak toad)		20
[1,2]*Bufo terrestris* (southern toad)		30,141
[2]*Gastrophryne carolinensis* (narrow-mouthed toad)		4,904
[2]*Hyla chrysoscelis* (Cope's gray treefrog)	observation only	0
[1,2]*Hyla cinerea* (green treefrog)		166
[1,2]*Hyla gratiosa* (barking treefrog)		1,880
[1]*Hyla squirella* (squirrel treefrog)		203
[2]*Pseudacris crucifer* (spring peeper)		8
Pseudacris nigrita (southern chorus frog)		2
[1]*Pseudacris ornata* (ornate chorus frog)		28
[1,2]*Rana catesbeiana* (bullfrog)		2,480
[2]*Rana clamitans* (green frog)		2
[1,2]*Rana utricularia* (southern leopard frog)		389
[1,2]*Scaphiopus holbrooki* (eastern spadefoot toad)		41
CLASS REPTILIA		
Order Crocodilia - Crocodilians		
Alligator mississippiensis (American alligator)		2
Order Chelonia - Turtles		
[3]*Deirochelys reticularia* (chicken turtle)		20
Kinosternon subrubrum (eastern mud turtle)		5
[1]*Trachemys scripta* (slider turtle)		64
Order Squamata - Lizards and Snakes		
Suborder Lacertilia - Lizards		
[2]*Anolis carolinensis* (green anole)		36
Cnemidophorus sexlineatus (six-lined racerunner)		2
Eumeces fasciata (five-lined skink)		2
Eumeces inexpectatus (southeastern five-lined skink)		2
Eumeces laticeps (broadheaded skink)		18
Sceloporus undulatus (eastern fence lizard)		2
[2]*Scincella lateralis* (ground skink)		35
Suborder Serpentes - Snakes		
[2,3]*Cemophora coccinea* (scarlet snake)		4
[2,3]*Coluber constrictor* (racer/black racer)		32
[3]*Crotalus horridus* (canebrake rattlesnake)		4
[2,3]*Diadophis punctatus* (ringneck snake)		1
[3]*Elaphe guttata* (corn snake)		3
[2]*Elaphe obsoleta* (rat snake)		2
[1,3]*Heterodon platirhinos* (eastern hognose snake)		18
[3]*Heterodon simus* (southern hognose snake)		1

Table 1. Continued.

Species	Number Collected
[3]*Lampropeltis triangulum* (scarlet kingsnake)	1
[1,2]*Nerodia fasciata* (banded water snake)	182
[3]*Sistrurus miliarius* (pygmy rattlesnake)	5
[3]*Storeria dekayi* (brown snake)	1
[2,3]*Storeria occipitomaculata* (red-bellied snake)	16
[2,3]*Tantilla coronata* (southeastern crowned snake)	24
[3]*Thamnophis sirtalis* (common garter snake)	19
[2,3]*Virginia valeriae* (smooth earth snake)	2
[3]*Sistrurus miliarius* (pygmy rattlesnake)	5

[1]Successful reproduction documented by presence of larvae, recent metamorphs, hatchlings or newborns.
[2]Species reported by Bennett (draft ms).
[3]Species is normally terrestrial in periphery of bays and other aquatic habitats.

being evaluated by using drift fences with pitfall traps and coverboard arrays in each of the treatment zones. Drift fences in five upland habitats were also established. Hoop turtle traps, funnel minnow traps, and dip nets are being utilized for aquatic sampling.

Results

A total of 47 species of amphibians and reptiles was collected or observed since May, 1993 (Table 1). Herpetofaunal groups were represented by the following percents by species: frogs and toads - 32%, snakes - 34%, lizards - 15%, salamanders - 1 1 %, turtles - 6%, and crocodilians - 2%.

Successful reproduction was documented for fifteen species (Table 1). Males of one additional species of frog were heard calling from the bay, but this observation indicates breeding activity and not necessarily successful reproduction.

Discussion

Our results indicate significant recolonization of Lost Lake by amphibians and reptiles. However, many of the species encountered inhabit a wide variety of wetland habitats, including areas that have been heavily disturbed.

Bennett (draft ms) conducted a similar study of Lost Lake herpetofauna in the summers of 1978 and 1979 prior to restoration in which he utilized drift fences with pitfall traps and coverboards on a smaller scale and did not use turtle or minnow traps. He documented only 27 species (Table 1), but those included two species not encountered in the present study. One specimen of the eastern coral snake (Micrurus fulvius), a secretive animal

Table 2. Amphibian and reptile species collected or observed in Carolina bays on the Savannah River Site, South Carolina (Schalles *et al.*, 1989; Gibbons and Semlitsch, 1991) but not collected or observed at Lost Lake in this study.

CLASS AMPHIBIA
Order Caudata - Salamanders
- *Amphiuma means* (two-toed amphiuma)
- *Eurycea cirrigera* (two-lined-salamander)
- *Eurycea longicauda* (long-tailed salamander)
- *Eurycea quadridigitata* (dwarf salamander)
- *Siren intermedia* (lesser siren)
- *Siren lacertina* (greater siren)

Order Anura - Frogs and Toads
- *Hyla avivoca* (bird-voiced treefrog)
- *Hyla femoralis* (pine woods treefrog)
- *Rana areolata* (crawfish frog)
- *Rana grylio* (pig frog)
- *Rana palustris* (pickerel frog)
- *Rana virgatipes* (carpenter frog)

CLASS REPTILIA
Order Chelonia Turtles
- *Chelydra serpentina* (common snapping turtle)
- *Chrysemys picta* (painted turtle)
- *Clemmys guttata* (spotted turtle)
- *Kinosternon bauri* (striped mud turtle)
- *Pseudemys floridana* (Florida cooter)
- *Sternotherus odoratus* (stinkpot)

Order Squamata - Lizards and Snakes
Suborder Serpentes - Snakes
- *Agkistrodon piscivorus* (cottonmouth)
- *Farancia abacura* (mud snake)
- *Farancia erytrogramma* (rainbow snake)
- **Lampropeltis getulus* (common kingsnake)
- *Nerodia floridana* (Florida green water snake)
- *Nerodia erythrogaster* (red-bellied water snake)
- *Regina rigida* (glossy crayfish snake)
- **Rhadinaea flavilata* (yellow-lipped snake)
- *Seminatrix pygaea* (black swamp snake)
- **Thamnophis sauritus* (eastern ribbon snake)

*Species is normally terrestrial in periphery of bays and other aquatic habitats.

associated with turkey oak-pine habitats, was collected in a pitfall trap. The dwarf salamander (Eurycea quadridigitata) was present in 1978-1979 but not encountered in the present study in spite of intensive sampling. It is possible that this species was extirpated from Lost Lake during the excavation activity or that the sparse vegetation now surrounding the bay does not provide adequate cover or shade for these animals.

Schalles et al. (1989) and Gibbons and Semlitsch (1991) list amphibian and reptile species collected or observed in other

Carolina bays on the Savannah River Site. A comparison with our results reveals 28 species not encountered at Lost Lake (Table 2). The absence of many of these species is not surprising since the bay is in a very early successional stage. We predict that as the wetland undergoes further succession, suitable habitats will allow recolonization by additional species.

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EFFECT OF SHORELINE TOPOGRAPHY ON VEGETATION DEVELOPMENT IN A PLANTED COOLING RESERVOIR

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Shoreline topography can affect environmental factors that, in turn, may determine composition or structure of vegetation communities. Coves may accumulate sediments and propagules, whereas more exposed points may be subject to greater wave energy and scouring (Keddy, 1982). Such abiotic factors may ultimately alter vegetation (Wilson et al., 1993). Consequently, in planted wetlands shoreline position may lead to differential development of vegetation and in sediment chemistry.

We examined the development of vegetation and sediment characteristics of unplanted and planted coves, points, and straights in a reservoir 5 yr after planting. The 400 ha once-through cooling reservoir, L-Lake, was constructed in 1985; approximately 5.7 km of the lakes shoreline was planted in 1987 (Wein et al., 1987).

We sampled vegetation and sediment at 9 planted and 7 unplanted coves, 4 planted and 7 unplanted points, and 8 planted and 6 unplanted straights. Percent cover was sampled in paired 1 X 1 m plots along a transect perpendicular to the shoreline at five

water depths (-1.00, -0.67, -0.33, -0.00, and +0.00 m). Additional transacts were added at larger sites. Sediments were only collected from the middle transect. Sediments were analyzed for pH, percent solids, cation exchange capacity, percent organic matter, and percent sand, silt, and clay. An additional 8 environmental variables were determined from field data or maps: site planted or not (PLANTED), shoreline distance from dam (DISTANCE), east or west shore (E/W), trees (TREES; +/-), number of transects (TR.), distance of shoreline sampled (SHORE), slope (SLOPE), and width of emergent vegetation (SHALLOW ZONE).

Mean vegetation cover for a site and 15 environmental variables were analyzed in a Canonical Correspondence Analysis (CCA) (Figure 1). Because of the large sample size, Axes 1 and 2 only accounted for 21.7% of the variance, with Axis 1 having 85% and Axis 2 having 79% species-environment correlations. Over all sites, plant composition was not correlated with a specific shoreline convolution but with DISTANCE, and PLANTED on Axis 1, and with SLOPE and SHALLOW ZONE on Axis 2. An analysis of sites by depth indicates that plant species composition of emergent communities (<-0.33 m) did not differ with shoreline type or planting. Submergent vegetation (-0.67 to -1.00 m) did differ with type and planting; planted coves had higher abundances of _Vallisneria americana_ and _Nelumbo lutea_, both planted species, whereas unplanted points and straights had either no vegetation or were dominated by _Potamogeton diversifolius_, an unplanted species.

As analyzed by ANOVA, sediment percent solids, pH, organic matter, texture, and CEC of coves were significantly different from points or straights (Figure 2). Planted locations and deeper water plots had greater percent silt and clay particles than unplanted and shallower water positions. After 5 years, there is a complex relationship among planting location, sediment characteristics, and vegetation that suggests that, with additional time, coves and points will differ if sediment characteristics begin to affect vegetation.

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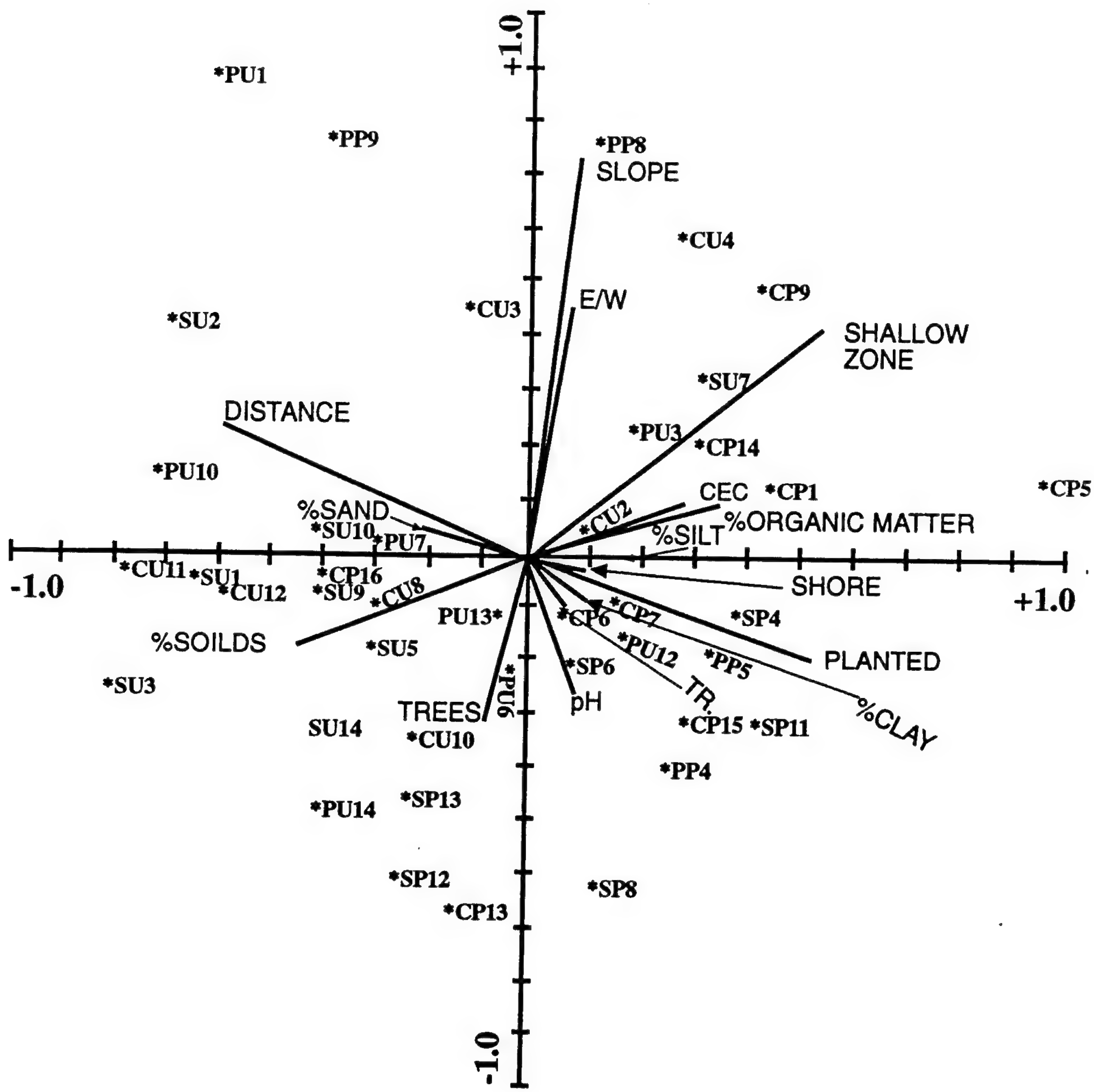

Figure 1. Axis 1 and 2 of a Canonical Correspondence Analysis of vegetation from 42 coves (C), points (P), and straights (S) from L-Lake showing relationships between sites and environmental variables. Second letter in the three letter site code refers to a planted (P) or unplanted (U) site; the third letter indicates a specific study site. See text for definition of environmental variables.

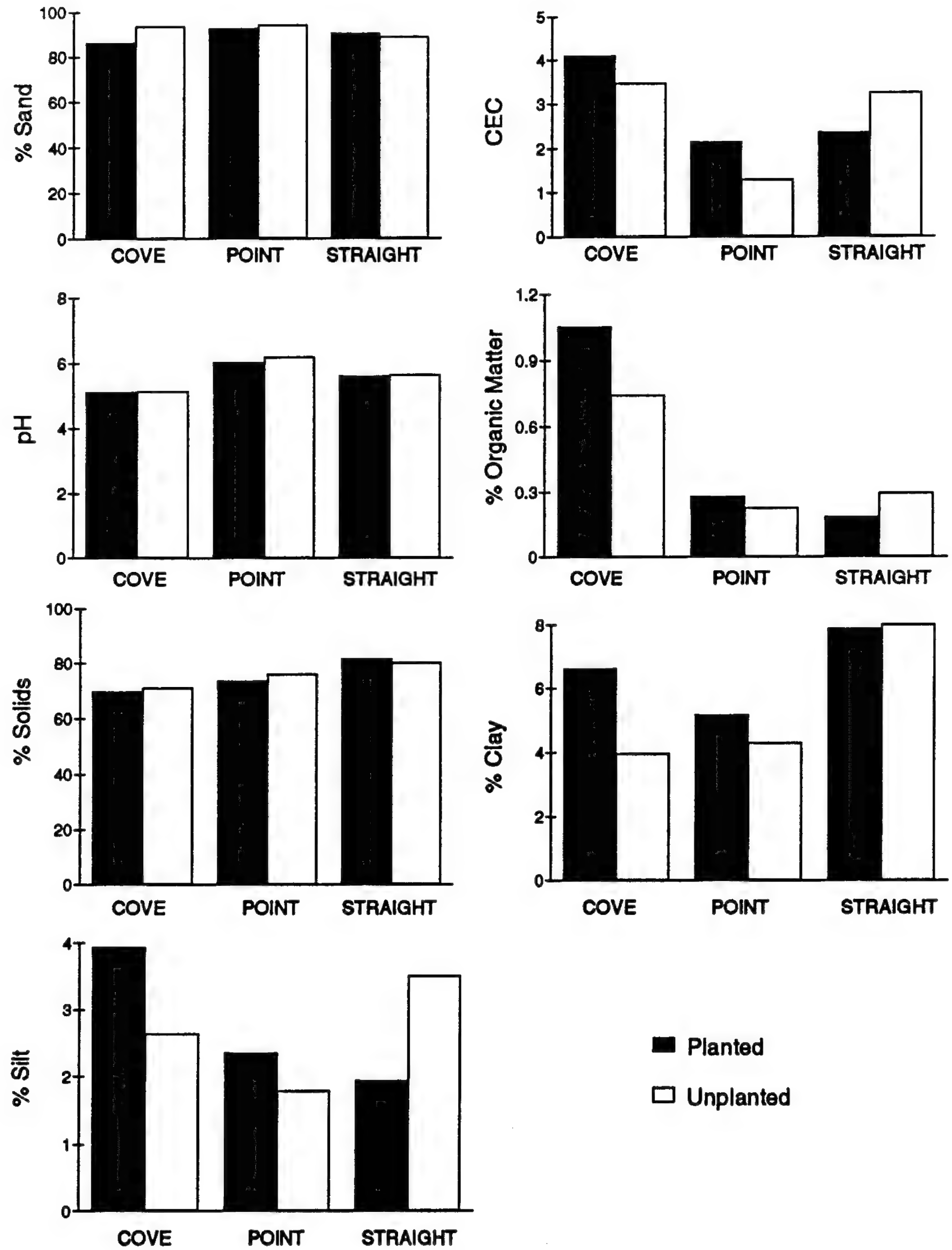

Figure 2. Mean percent solids, pH, percent organic matter, cation exchange capacity, and percent sand, silt, and clay of sediments from planted and unplanted coves, points, and straights collected from 42 locations in L-Lake.

SESSION RE4

RESTORATION, PROTECTION, AND CREATION: COASTAL CREATION AND RESTORATION PROJECTS IN CALIFORNIA

Dr. Robert N. Coats, Chair

MODELING FOR WETLAND RESTORATION AND STORMWATER MANAGEMENT AT THE BALLONA WETLANDS, LOS ANGELES, CALIFORNIA

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The Playa Vista Project, being planned by Maguire Thomas Partners-Playa Vista, is located near the Ballona Creek outlet to the Pacific Ocean in Los Angeles, CA. The Ballona Wetlands are located at the western end of the project site and immediately adjacent to the south side of the channel. These wetlands, which have been cut off from tidal flows since the 1930's, are the largest remaining coastal wetland (approximately 186 acres) in Los Angeles County. Current plans propose restoration of tidal influence over approximately 191 acres of salt marsh and the creation of an 51-acre freshwater wetland system.

Because the wetlands currently provide stormwater management and detention functions, it was necessary to incorporate these wetland functions into the design of the wetland restoration/creation project. A complex hydrodynamic model was developed utilizing EPA's Storm Water Management Model (SWMM, EXTRAN). EXTRAN models the dynamic routing of stormwater flows using an explicit technique to solve gradually varied flow equations. The model allows the sizing of storm drain pipes and wetland circulation channels and the computation of water surface elevations under both storm conditions and tidal influence. The results show that EXTRAN is a valuable tool to conduct studies involving storm and tidal water routing through channels and conduit networks and linked reservoirs.

DESIGNING A MULTI-FUNCTIONAL FRESHWATER WETLAND SYSTEM AT THE BALLONA WETLANDS, LOS ANGELES, CALIFORNIA

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The Playa Vista Project, being planned by the Maguire Thomas Partners-Playa Vista, proposes to construct a 51.5-acre multi-functional freshwater wetland system in a highly urbanized area. This freshwater wetland system will create a new wetland mitigation habitat area while providing for the passage of stormwater flows, for the cleansing of urban run-off, and for management of freshwater inflows into an adjoining area to be restored as salt marsh. Specific goals of the system are to ensure no net loss of wetlands and no increase of pollutants flowing into the Ballona Channel and Santa Monica Bay.

To achieve these wetland functional goals, a multi-disciplinary design team was assembled that used a collaborative design approach. Such an approach required the integration of the design tools from the different disciplines. For example, to address hydraulic and water quality issues, the team coupled the SWMM model with the City of Los Angeles; hydraulic design methodology and EPA's detention basin methodology. Habitat components were then defined by a habitat model for southern California's freshwater riparian systems. To achieve the desired goals, both on-site and off-site best management practices were also incorporated into the design. Finally, the team developed monitoring and maintenance plans to ensure that the project would attain and retain the desired wetland functions and values.

USING GEOMORPHIC RELATIONSHIPS IN DESIGNING TIDAL SLOUGH CHANNELS

Robert Coats, PhD, Kelly Cuffe, M.S., Philip Williams, PhD, PE
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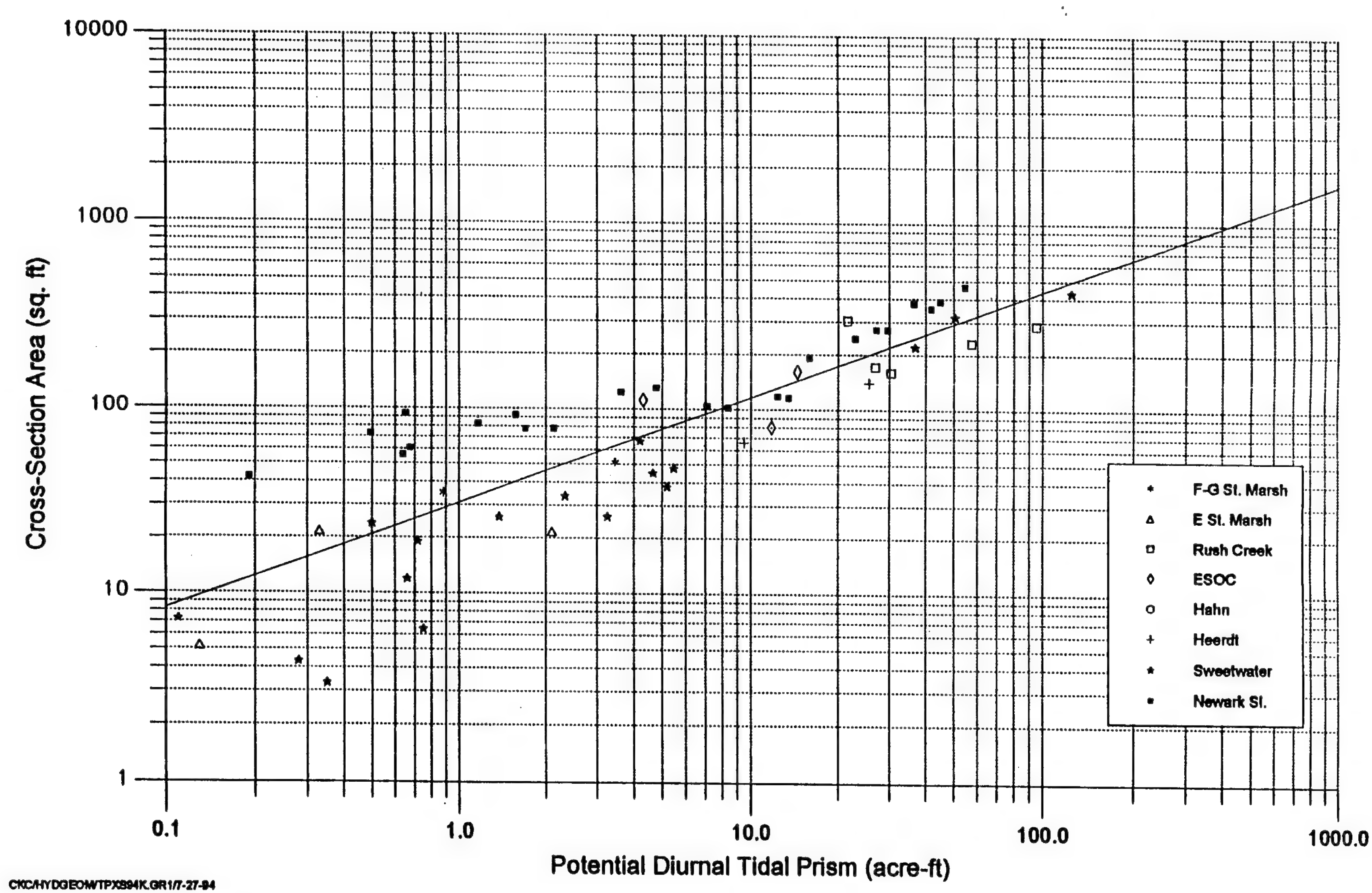
Recent interest in wetland restoration and enhancement has created a need for quantitative tools that can be used to design tidal slough channels. In an effort to develop empirical geomorphic relationships for natural tidal marshes that can be used in designing the cross sections and planform geometry of tidal slough channels, we 1) surveyed the literature on the geomorphology of tidal marshes for North America and England; 2) documented the ecological values of tidal slough channels; and 3) developed data sets from field surveys in tidal marshes of San Francisco and San Diego Bays. These derived relationships have proven useful in designing levee breaches, inlet channels across existing marsh plains, and channel systems in dredged material (Coats, et al., 1995).

The usual formulation of hydraulic geometry relationships is to express channel width, depth and velocity as exponential functions of discharge (Chantler, 1974). Since discharge varies over a tidal cycle, and is difficult to measure, it is not a very useful design parameter. As a surrogate for discharge, we measured Potential Diurnal Tidal Prism (from detailed topographic surveys), and plotted that variable against marsh area, maximum channel depth below MHHW, channel width at MHHW and channel cross sectional area, for 8 California tidal marshes. Few comparable data from other studies were found, but the available data are consistent with the data set for California. Figure 1 shows the data for channel cross sectional area vs. Potential Diurnal Tidal Prism, for the California marshes studied.

This approach assumes that there is some dominant or channel forming discharge associated with a given tidal prism. It is not obvious, however, what tidal prism should be used as an independent variable. The effective discharge may be associated with tides that extend over the marsh plain, and create surges in velocity during ebb (Pethick, 1980). Plotting the channel geometry data for one marsh against Spring Tidal Prism rather that Diurnal Tidal Prism provided virtually no improvement in the correlation coefficient.

Average channel side-slopes were calculated for a natural marsh in San Francisco Bay. The results are consistent with the range of values expected for saturated cohesive sediments, based on literature values for shear strength (Pestrong, 1973).

Channel planform characteristics (sinuosity, bifurcation ratio and drainage density) vary widely among tidal marshes. The



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CHANNEL CROSS-SECTIONAL AREA VS. TIDAL PRISM IN TIDAL SLOUGHS

FIGURE 1

range of these variables was calculated for some natural marshes in order to provide a basis for design. Drainage density varied between 0.01 and 0.02 ft/ft^2 and bifurcation ratio was consistently about 3.5. Channel sinuosity averaged 1.1 for first order channels, and 2.0 for third to fifth order channels.

Acknowledgments

We thank Denise Reed, Joy Zedler, Steve Watry and Jay Noller for their contributions to this study. We thank Steve Maynord of the Corps of Engineers Waterways Experiment Station for his helpful comments and patience. This work was supported in part by Contract DACW39-93-C-0126 of the U.S. Army Corps of Engineers.

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A RETROSPECTIVE ON A "WIN-WIN" WETLANDS MITIGATION PROJECT: CREATION OF THE WARM SPRINGS MARSH IN SAN FRANCISCO BAY

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This 10 year old marsh is the largest project of its kind in South San Francisco Bay. Formerly part of the historic marshes of San Francisco Bay, the project site evolved to diked, seasonal wetlands. Offered as mitigation for a Corps permit, the project replicated 40 acres of seasonal wetlands and created over 200 acres of new marshes. Storm waters are retained in the seasonal wetlands, saving over a million yards of imported fill. Corps and FEMA flood protection for a 500 acre complex of business parks and public access with set-asides for endangered species accompanied the marsh restoration. The rapid growth of the marsh has been plotted,

yielding important data about marsh creation efforts in San Francisco Bay.

The Bayside Business Park is one of Fremont, California's most successful business parks and while business people like it, shorebirds and joggers are equally enthusiastic. The 500-acre project set aside over 260 acres for mitigation-related purposes and remains the single largest expansion of San Francisco Bay by a private entity. Constructed over ten years ago in an area of uplands intermingled with diked historic baylands that had been converted to low intensity agricultural uses, the project had to mitigate the fill of lower laying elevations that were considered seasonal wetlands. To do so required the careful mapping and cataloging of wetlands along with an innovative grading and drainage study. The final design required the developer to excavate over 200 acres, introduce tidal flows, construct a storm water retention basin that would replicate the seasonal wetlands characteristics being lost, set aside a 40 acre vegetated stand of pickleweed (Salicornia virginica) that was the presumed habitat for the federally endangered Salt Marsh Harvest Mouse (Reithrodontomys raviventris) and provide public access.

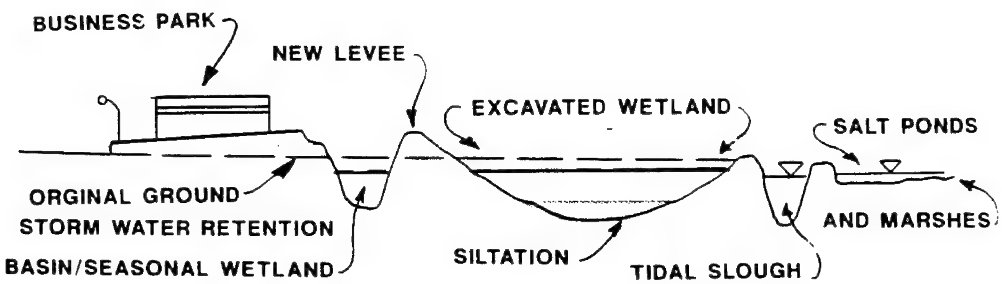
The key component of the marsh restoration was the excavation of over 1 million cubic yards of material from the site. This material was then reused as engineered fill for the business park and the new levees that separated the restoration site. The face of the new levee protecting the business park was buttressed with rip rap and then the rip rap was covered by a gentle 20:1 slope in the inter-tidal range.

During most of the year, since California has a Mediterranean climate, the storm water retention basin functions as a seasonal wetland. Storm channels leading into the basin were designed and constructed in a non-linear fashion to replicate the small sloughs that traversed the historic wetlands.

Surveys by consulting biologists have shown that the restored marshes have a greater density of shorebird use than nearby seasonal wetlands that mirror the site's previous characteristics. The marsh silts accumulated rapidly in the first few years after the restoration site was opened to tidal action. New marsh surfaces that would be exposed at least once a day during the lower of the two tides were designed to flatter, 4:1 gradients, with the assurance that the siltation process would quickly soften and smooth out the exposed surfaces.

No revegetation was required in the permit process on the assumption (proved correct) that the process would occur naturally. While the marsh appears totally successful to the casual observer some lessons were learned. The original design called for the existing levee to be breached in three locations. Only two breaches were excavated and one was too narrow to allow totally

adequate tidal flows. The result was that siltation and restoration occurred more rapidly in the southern end of the marsh where adequate flows for sediment transport where available. Despite that flaw, the restoration remains a one of a kind effort in South San Francisco Bay and continues to receive approval from its users, both human and otherwise.



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BIOTECHNICAL BANK STABILIZATION AND HABITAT RESTORATION: PETALUMA RIVER

Richard Nichols, Richard Meredith, and Andrew Leiser, PhD
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Undercutting and riverbank erosion were threatening the site for a proposed factory outlet shopping mall, recreational biketrail, and associated riparian habitat restoration project. High flows in the Petaluma River in February 1993 undercut the riverbank, causing a large willow tree to fall in the channel. Subsequent flows were diverted by the obstruction towards the bank downstream, resulting in further undercutting and sloughing. The result was a loss of several feet horizontally from the top of bank and a steep, barren and unstable slope (Figure 1).

Other areas along the project riverbank showed evidence of less severe undercutting. Additional concerns focused on the stability of the bank to support a proposed bridge. A purely biotechnical approach without use of structures or riprap was required by the City of Petaluma to achieve both erosion control and habitat restoration objectives without the need for a Section 404 permit, which would have disrupted project schedules. Based on information from a consulting hydrologist, treatments needed to be designed to withstand velocities up to 12 feet per second.

Due to these extreme forces and the high values at risk, it was apparent that an intensive and innovative treatment was required for the severely eroded area. The resulting plan (Figure 1) proposed installation of planted fascines installed on contour in three to four rows along the bottom half of the bank, beginning at the low flow water line. High density Fiber Rolls) manufactured by Bestmann Green Systems were selected for fascines due to their ability to thwart high velocity flows and provide a secure medium for revegetation without using hard structures.

The Fiber Rolls used on the project are composed of shredded coconut husk fiber ("coir") packed at nine pounds per cubic foot into a polyethylene mesh netting exterior. They are one foot diameter cylinders, twenty feet in length and weighing 144 pounds each when dry. Instead of the brush matting called for in the plan (Figure 1), a field change resulted in installation of five inch thick coir fiber mats between the fascine rows. The plan called for the top half of the bank to be secured by three rows of contour wattling. Contour wattling in this case is composed of live willow (Salix spp.) cuttings tied into cigar shape bundles averaging five feet in length and eight inches in diameter, and staked end to end to form linear rows (Gray and Leiser 1982). The plan proposed planting the entire bank densely with native herbaceous wetland species. Planting of riparian trees and shrubs was planned only for the top half of the bank to prevent obstruction or diversion of

flows.

Implementation began with careful grading of the vertical portions of the top of the bank using a backhoe to create a more gradual slope (1:1 to 1.5:1) for improved stability and larger planting area. A row of hay bales was staked along the lower bank prior to grading as a sediment trap which prevented any soil from falling in the river. The coconut fiber rolls were installed securely with wooden stakes cut diagonally from four foot long two by fours and anchored by a network of polypropylene cord. The upper bank was protected with rows of wattling trenched and wedged in with wooden stakes. Areas between the fiber rolls and wattling were staked and tied down with coir mattresses. Areas less severely undercut and the bridge abutment areas were treated with a single fascine row slightly below the low flow water line.

The stabilized bank withstood high flows (measured up to 6.5 feet per second) the first winter, even prior to establishment of vegetation (Figure 2). A total of approximately 9500 herbaceous wetland species were collected from the site and contract grown in 1 1/2" by 10" size containers. Planting on about 18-inch centers commenced in the spring of 1994. Common tule (*Scirpus acutus*) was planted directly into the outermost and lowest fascines with alkali bulrush (*S. robustus*) and waterpepper (*Polygonum hydropiperoides*) at slightly higher elevations.. The upper bank was planted with sedge (*Carex* spp.), umbrella sedge (*Cyperus eragrostis*) and Baltic rush (*Juncus balticus*). A temporary irrigation system was installed to allow for establishment during the dry summer. Willow sprouts from the wattling had attained heights up to eight feet by July, and the herbaceous species were rapidly covering the slope (Figure 2). A total of 816 native riparian woody species such as California box-elder (*Acer negundo* ssp. *californica*) and Oregon ash (*Fraxinus latifolia*) were planted in the fall of 1994.

Treated areas and plantings remained intact after a 15-year flood on January 10, 1995 that sent high flows over the top of bank, while some undercutting and sloughing occurred on adjacent untreated areas. Consulting biologists will continue to supervise additional plantings and monitor the success of the project for the City of Petaluma until 1999. Monitoring of vegetative recovery and wildlife use has already shown that a previously eroding riverbank with low scenic and wildlife values has been stabilized and restored to a viable native riparian habitat (Figure 2).

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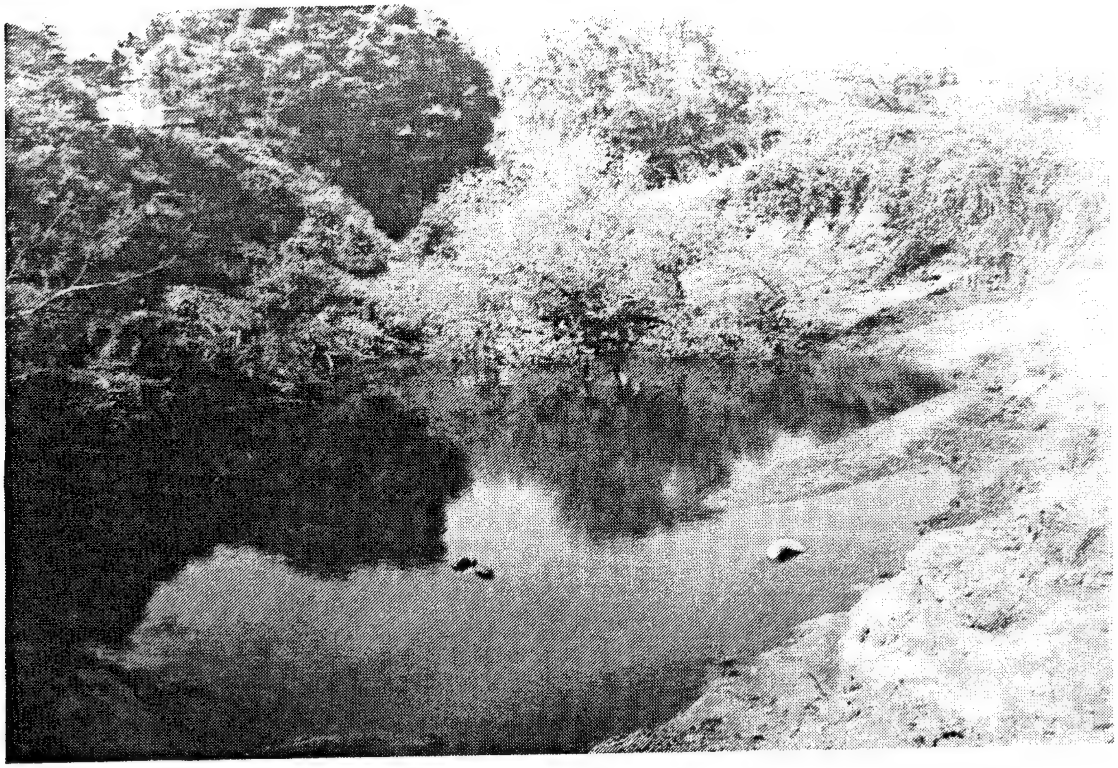
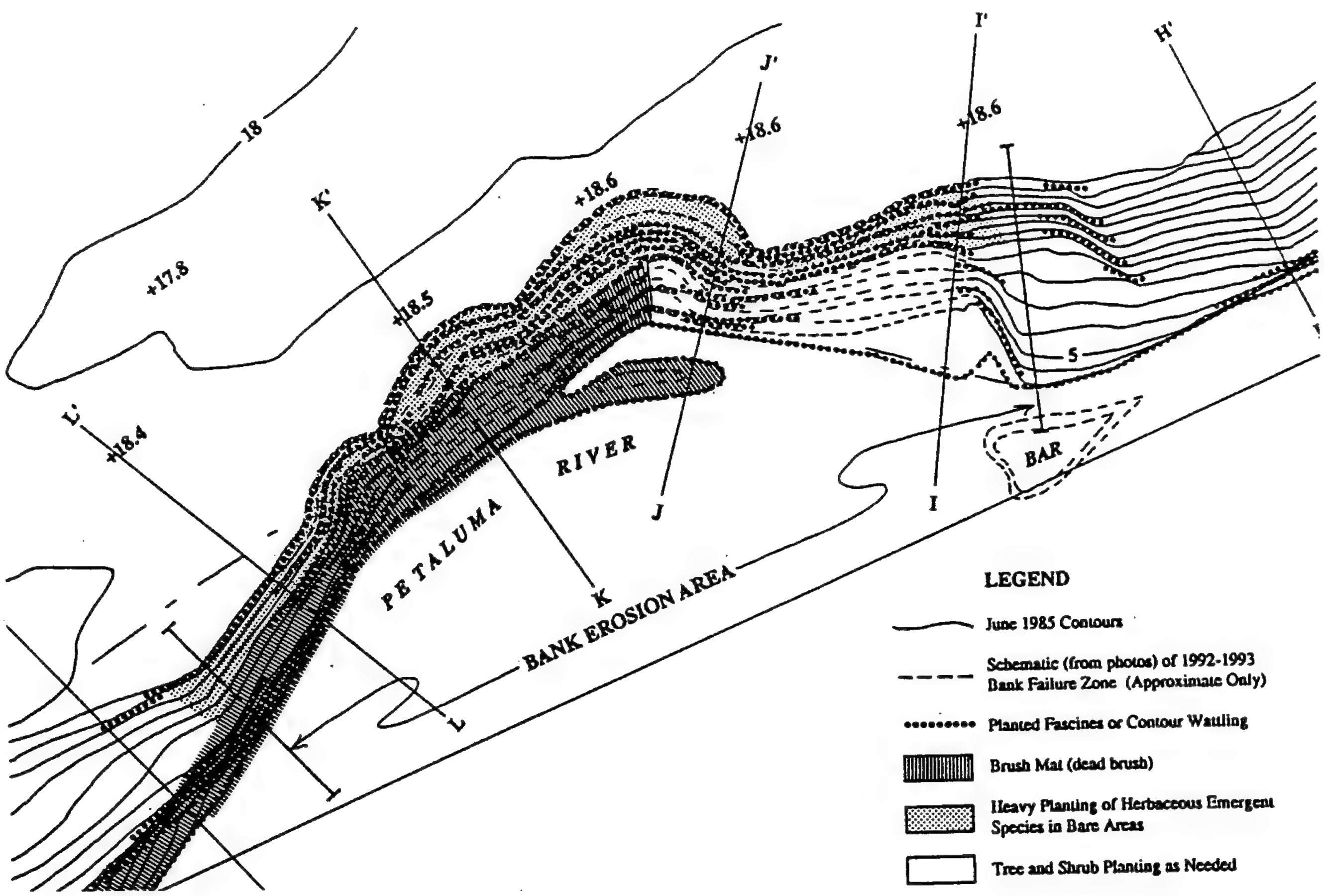


Severely eroded riverbank prior to treatment. (Note: Fallen willow tree in background) (May 1993)



Biotechnical Bank Stabilization Plan for Eroded Bank, Petaluma River, California.

FIGURE 1

Treated riverbank after installation but prior to planting. (February 1994)

Treated riverbank after establishment of vegetation. (September 1994)

FIGURE 2

SESSION ID2

IDENTIFICATION AND DELINEATION II

Ellis J. Clairain Jr., Chair

A COMPARISON OF FIELD DELINEATED WETLAND AREAS VS. NWI MAPPING AND SCS HYDRIC SOILS MAPPING

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Four land parcels, totaling approximately 5500 acres, located in northern Virginia, have been delineated under the 1987 Manual, approved by the US Army Corps of Engineers, and located by tape and transit survey. These areas of Jurisdictional Wetlands have been compared to wetland areas shown on NWI maps and soils mapped by the SCS and listed as hydric. This sampling of several large sites has confirmed the author's anecdotal evidence (based on hundreds of small sites in this geographic area) that in Northern Virginia (1) NWI maps typically significantly understate the areas of Jurisdictional Wetlands, and (2) SCS hydric soil maps significantly overstate the area of Jurisdictional Wetlands, that can be expected on a site. This quantitative analysis of available inventory resources vs. precisely defined resources has important ramifications for people undertaking land use plans, land acquisition decisions, and natural resource status predictions.

DELINEATION AND MAPPING OF WATERS OF THE UNITED STATES (WoUS) ON THE PLAYA, U.S. ARMY DUGWAY PROVING GROUNDS, UTAH

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Introduction

US Army Dugway Proving Ground (DPG) is an active military installation which develops and tests defensive weaponry and provides a site for infantry training and maneuvers. DPG encompasses about 850,000 acres and is located southwest of Salt Lake City in the Great Salt Lake Desert of Utah. DPG includes the desert playa of ancient Lake Bonneville. Created by annual storm

water run-off and snowmelt, this playa is essentially barren in the center since it is saturated with water for about 9 months of the year and has high salinity and alkalinity levels (USDA n.d.). Only occasional sand dunes and hummocks provide a growth medium for a few desert species. However, environmental conditions are less extreme near the edges of the playa so the types and abundance of plant species increases. This setting makes accurate wetland delineation difficult when based on the traditional parameters of hydrophytic vegetation, hydric soils, and a wetland hydrologic regime.

Methods

In the fall of 1993, DPG authorized the Corps of Engineers to delineate, map, and provide general management recommendations for Waters of the United States (WoUS) on the playa. The project was conducted in two phases due to the size of the playa and seasonal limitations. Phase one included the delineation and mapping of a small portion of the eastern boundary of the playa, and phase two was a concerted effort to delineate and map the entire 25-square mile playa. The primary goal of the project was to accurately delineate and map the playa and its transition zones using the methods outlined in the Corps of Engineers Wetland Delineation Manual (1987). A secondary goal was to determine if the traditional three-parameter method of delineation is valid in a desert playa environment.

For phase one, the Corps contracted with an experienced environmental firm, Environmental Science Associates (ESA), to delineate and map the smaller portion (ESA 1994). In phase two, the Corps used the Waterways Experiment Station (WES) to delineate and map the entire playa. Initially, the ESA and WES teams used existing SCS orthophoto quadrangles, soil surveys, existing information on vegetation and hydrology, and digital GIS maps provided by DPG as base information. High altitude photos provided by DPG and photos taken during helicopter overflights of the area oriented the teams to potential wetland boundaries and provided visual confirmation of data in base information sources. The teams "ground-truthed" the playa during the late spring and fall of 1994 to sample soils and vegetation and to verify the hydrology of the playa. The WES team also used Global Positioning System (GPS) equipment mounted in a helicopter to fix data points along the boundaries of the playa. The combination of the GPS points and orthographic rectification of photographs yielded a very accurate boundary line.

Results

This two-phase project accurately delineated and mapped the playa on DPG. The studies found that the playa constitutes 422,796 acres of the 850,000 acres of DPG. The project confirmed that a significant portion of this playa qualifies as WoUS (33 CFR

328.3). The combination of the playa, sand dunes, and spring complexes yields 426,516 acres of WoUS. The playa as a whole is considered a "special aquatic site" since it contains areas which produce brine shrimp and flies which are food for migrating shore birds. The final reports and GIS maps allow DPG to more effectively manage and protect this valuable natural resource while accomplishing its military missions.

Discussion

This delineation project confirmed that vegetation type and percent cover are not reliable indicators of WoUS on a desert playa. Although some areas had less than five percent vegetative cover, they did have hydric soils and an appropriate hydrologic regime. Surface soil characteristics including color, texture, structure, and general topography are more accurate WoUS indicators. This results of the project indicate that the technical criteria used to define a WoUS, as it applies to western deserts, may need to be reviewed and modified to include the unique characteristics of a playa.

Acknowledgments

I thank Mr. Carl Jorgensen, Director of Environmental Programs at DPG; Mr. Robert Lichvar, WES Team Leader; and Dr. Kathy Cuneo, ESA Senior Wetland Specialist, for their cooperation and professional expertise.

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A COMMON ERROR IN ASSESSING HYDROPHYTIC VEGETATION FOR WETLAND IDENTIFICATION

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Introduction and Background

The Corps of Engineer's 1987 Wetland Delineation Manual (1987 Manual) contains a criteria that wetland plant communities must be dominated by hydrophytes. The 1987 Manual provides several indicators to determine if the criteria is met. The field indicator that is considered the strongest is based on determining the dominant species in the plant community. A positive indicator of hydrophytic vegetation requires that over 50% of the dominant species in an areas be categorized as facultative (FAC; excluding FAC- species), facultative wet (FACW) or obligate (OBL) in the National List of Plant Species that Occur in Wetlands. (Reed, 1988).

A widespread problem has been noted in that most practitioners treat this field indicator as a criteria or "standard" that must be met in order to designate an area as a wetland; and the nationally sponsored federal classes in wetland delineation present this indicator as a criteria. In our experience as instructors in both national and regional classes and in reviewing hundreds of wetland delineation reports we have noted that this common misinterpretation of the 1987 Manual has resulted in both false-negative and false-positive determinations of hydrophytic vegetation.

Sampling and Results

Plant communities were characterized in forested and herbaceous wetlands occurring commonly at low elevations in the Pacific Northwest. Methods used were consistent with those described in the 1987 Manual. In the herbaceous community, quantitative sampling using a point quadrat method was used to supplement other methods.

Forested Community: This community is a mature forested wetland adjacent to a small lake. Both the canopy layer and shrub layer can be easily assessed using visual estimates of dominant species. Results are presented in Table 1. These data show that 20% of the dominant species are FAC, FACW or OBL, which does not provide a positive indicator of hydrophytic vegetation.

Herbaceous Community: The herbaceous community was located adjacent to a large lake in an area where the woody vegetation had been removed a half century or more ago. Vegetation was sampled in spring, summer and fall seasons. Dominant species in different seasons varied, however the results were the same relative to the hydrophytic vegetation indicators in the 1987 manual. Results

obtained in the spring of 1994 are shown in Table 2. These data show that 50% of the dominant species are FAC, FACW or OBL which does not provide a positive indicator of hyrophytic vegetation. (Note: It is interesting that our analysis of an adjacent upland plant community would provide a positive indicator of hydrophytic vegetation i.e. a false positive).

Discussion and Conclusions

In both communities, if plant indicator status is applied as a criteria or inflexible "standard", neither community would be considered hydrophytic. However, field evidence considered in total (see table 3 for soils and hydrology notes) clearly indicate the areas to be wetlands (see table 2). Indeed, the forested community represents a classic forested peat wetland common throughout the northwest and nearly all investigators would easily recognize it as a wetland. On the other hand, our experience indicates that many practicing wetland delineators would conclude that the herbaceous community is not a wetland There are several explanations for reaching such a conclusion:

1. Misunderstanding regarding the list of plant species that occur in wetlands. Some investigators incorrectly interpret that the list provides a basis for concluding that most or all the dominant species in all wetlands will be categorized as FAC, FACW or OBL.

2. Treatment of the indicator in the Corps Manual as a criteria or standard.

3. Seasonal variation. During some times of year, plants such as summer annuals may populate an area which temporarily leads to a false negative conclusion regarding the occurrence of hydrophytic vegetation.

We do not believe that problems in verifying the occurrence of hydrophytic vegetation in areas like those described above are caused by incorrect categorization of plants in the National List of Plant Species that Occur in wetlands. It is clearly possible for species which occur up to 1/3 of the time in wetlands to be the dominant species in some wetland vegetation communities. Avoidance of this type of error can be achieved by:

1. Learning to recognize those plant communities which are commonly dominated by plants with facultative upland (FACU) indicator status

2. Proper interpretation of the 1987 manual.

3. Avoiding wetland delineation methodologies which have simplistic, numeric, inflexible "criteria" based on the species lists. Such methods do not recognize natural variability or adaptability of individual species (Tiner, 1991)

Table 1: Dominant species of the forested community

Dominant species	Vegetative Layer	Indicator status
Tsuga heterophylla	canopy	FACU
Tsuga heterophylla	shrub	FACU
Gaultheria shallon	shrub	FACU
Tsuga heterophylla	herb	FACU
Lysichitum americanum	herb	OBL
Sphagnum sp.	herb	No indicator

Table 2: Dominant species of the herbaceous community.

Dominant species	Indicator status
Circium arvense	FACU
Agropyron repens	FAC-
Holcus lanatus	FAC
Equisetum telmateia	FACW

Table 3: Notes on Hydrology and Soils

Forested Community:

- Soils are undrained histosols which match the description of the Seattle Muck series.
- Multiple observations over a 2-year period indicates that soils are saturated to the surface throughtout the year.
- Shallow well data indicates that the water level is within 4 inches of the surface throughout the year.

Herbaceous community:

- Soils match the description of the Sammamish series, a hydric soil. Verified by soil scientists from the NRCS Technical Center, by the Washington State Soil Scientist and by the Area Soil Scientist.
- Multiple observations over a two year perioid indicate that soils are saturated to the surface for a minimum of 90 days during the growing season.
- Data from shallow wells demonstrated that water levels were within 4 inches of the surface between March 4 and May 10, 1994. Similar results obtained in other years.

4. Integrate information on soils, hydrology and vegetation when making wetland delineations. Avoid approaches which treat soils, vegetation and hydrology as independent variables.

5. Provide training which goes beyond cookbook approaches.

Seattle District of the Corps of Engineers and EPA Region 10 have addressed this problem by issuing supplementary guidance on interpretation of the 1987 manual. This guidance is explained in a paper presented by Knaub et al. at this workshop.

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WASHINGTON REGIONAL GUIDANCE ON THE 1987 WETLAND DELINEATION MANUAL

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Seattle, Washington

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Introduction and Background

The Seattle District published regional guidance on the Corps' 1987 manual to provide clarification on parts of the manual that have been misinterpreted by wetland consultants in our District. The guidance clarified how to determine jurisdictional limits with the 1987 manual and was prepared by an interagency group with input from private sector representatives.

The six issues that were addressed in the guidance were: interpretation of hydrophytic vegetation indicators, other hydrophytic vegetation field indicators, methods for analyzing vegetation communities, growing season, interpretation of normal circumstances and interpretation of hydrologic data.

Four of these issues, hydrophytic vegetation indicators, analyzing vegetation communities, growing season, and hydrologic data are discussed in this paper.

Discussion

The first issue, interpretation of hydrophytic vegetation indicators, provides clarification on identifying wetlands that are dominated by FACU categorized species. Wetland delineators in Washington state encounter FACU dominated wetlands in much greater frequency than would be expected based on their frequency of occurrence across the landscape. Specific wetland communities in Washington State are discussed in a paper presented at this workshop by Weinmann and Kunz.

The 1987 manual provides several indicators of hydrophytic vegetation. However, Seattle District found that many manual users were only using "indicator a" which states "More than 50% of the dominant species (in a plant community) are OBL, FACW, or FAC on lists of plant species that occur in wetlands". Delineators were ignoring "indicator b" which states "Visual observation of plant species growing in areas of prolonged inundation and/or soil saturation". (See page 23 of the 1987 manual). In general, if hydrology and soils criteria are clearly met, then an area has prolonged periods of inundation or saturation. Under those circumstances, a delineator could determine that the plant species are growing under wetland conditions. This is consistent with the Diagnostic Environmental Characteristics of the 1987 manual.

The District guidance emphasizes caution in using "indicator b". A delineator should assure themselves that the hydrology is not the result of unusual flooding, high rainfall or a temporary water diversion. Investigators should rely on their previous experience with the plant community, consultation with other experienced delineators and the literature to determine if the vegetation community is known to occur in areas of prolonged inundation or soil saturation. In addition, information sources should be documented within the report.

The guidance also discussed the use of Data Form 1 in the 1987 manual. Data Form 1 appears to require the presence of three vegetation layers with at least three dominant species in each layer for a hydrophytic vegetation determination. However, in low diversity communities, dominants will be less than three and may only be one. Recent Corps headquarters guidance on the manual stated that other ecologically based methods for selecting dominant species from each stratum were acceptable.

Guidance was also provided on determining the growing season. In much of the Northwestern U.S., some plant species are growing during every month of the year. The District guidance recommended that wetland delineators use sound professional judgment based on

careful observation to determine if the growing season is in progress. Observation of recent plant growth such as flowers, new shoots, new leaves, or swollen buds, as well as taking soil temperatures at 19.7 inches was recommended if the presence of the growing season, as determined through the data tables in the soil surveys, is in question. The guidance emphasized that although the mesic growing season, i.e., 1 March to 31 October, can be used as a rule of thumb in much of Western Washington, this should not be used to conflict with field data observations.

The issue of interpretation of hydrologic data was also discussed in the District guidance. Seattle District had found that many delineators were spending considerable time and effort installing and monitoring ground water wells, without recording data on soil saturation. However, the hydrology criterion in the 1987 manual states that "The area is inundated either permanently or periodically at mean water depths < 6.6 ft., OR the soil is saturated to the surface at some time during the growing season of the prevalent vegetation." (Page 14, Diagnostic Environmental Indicators.) Under "Field Indicators of Hydrology" the manual states: "For soil saturation to impact vegetation, it must occur within a major portion of the root zone (usually within 12 inches of the surface) of the prevalent vegetation." (Page 38, field indicators.)

The guidance emphasized that while well data can be extremely useful, supplemental observations of surface soil saturation and/or observations of surface ponding or flooding, are needed as well.

Conclusion

The District's supplementary guidance on interpretation of the 1987 manual has helped to improve the accuracy of wetland determinations in the Seattle District. Copies of the guidance can be obtained by contacting Debbie Knaub at the Seattle District or Fred Weinmann at the Environmental Protection Agency, Region 10.

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CRITICAL PROCESSES: WETLAND VEGETATION I

Jack E. Davis, PE, Chair

WETLAND PLANT DIVERSITY AND EVAPLTRANSPIRATION IN AGRICULTURAL LANDSCAPES

D.H. Rickerl, J.H. Gritzner, and C. Lafay

Abstract

The diversity and distribution of wetland plant species is generally related to soil seed banks, growth habit, and water depth. The objective of this study was to determine the impact of farm management practices on wetland plant distribution, diversity and subsequent evapotranspiration. Plant populations were determined for seasonal wetlands in organic and no-till farming systems. Evapotranspiration was measured using insitu plant lysimeters. Plant distribution was related to water depth. Species diversity in the transitional no-till system was less than in the organic system. Evapotranspiration rates were significantly different among the species early in the season, but differences diminished as the season progressed. Farm management practices which alter wetland species have the potential to alter evapotranspiration losses in wetlands.

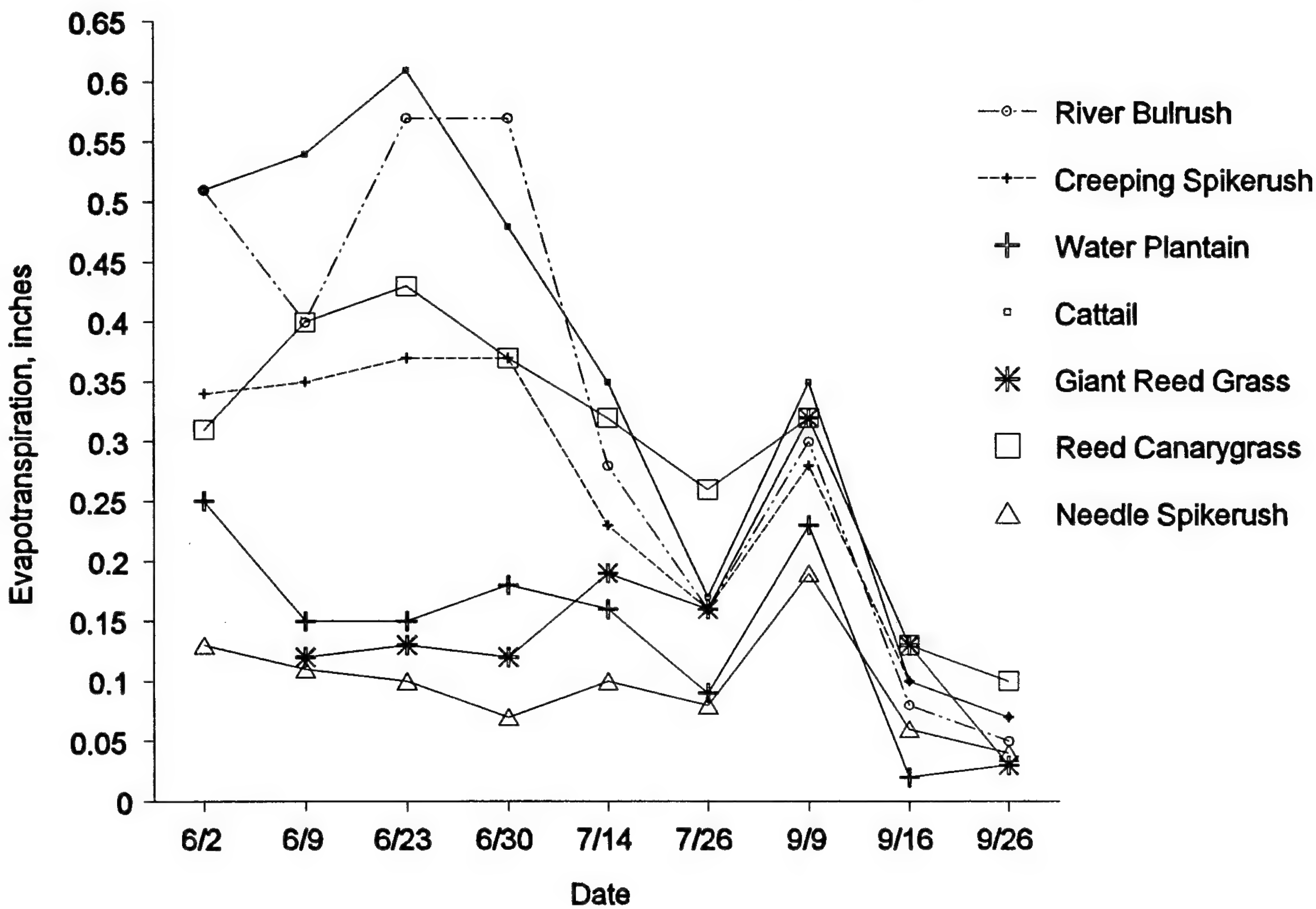
Introduction and Site Description

South Dakota lies in the Prairie Pothole Region of the US and still retains 65% of its natural wetlands. These wetlands provide typically cited roles and functions and may be critical to soil moisture recharge for production of agricultural crops. Seasonal wetlands in organic (ORG) and transitional no-till (TNT) agricultural systems in the Prairie Pothole Region of eastern South Dakota were chosen for investigation. The ORG system used manures and crop rotations to replace synthetic fertilizers and pesticides. The TNT system used no-till planting techniques to reduce soil erosion and recommended rates of fertilizers and pesticides. The objectives of the study were to determine the effects of these two farming systems on wetland plant diversity and subsequent evapotranspiration losses from the wetlands.

Methods

In order to determine plant diversity, plant samples were collected at 75 m intervals around the wetland perimeter. At each

Figure 1. Evapotranspiration (inches) as influenced by wetland plant species during the 1994 growing season.



collection interval, an axes extending through the wetland vegetation was used to collect samples at fifty foot increments. Plant samples collected at each data point consisted of three randomly chosen, 0.3 m square samples. The plants were identified according to species and populations of each species were determined. Plant lysimeters were used to determine evapotranspiration losses for cattail, reed canary grass, river bulrush, creeping spike rush, giant reed grass, water plantain, and needle spikerush.

Results

Wetland plant diversity was greater in the organic than the transitional no-till system. Diversity also increased along the sampled axes as you moved away from the deep water zone. Early in the growing season, significant differences in transpiration rates occurred between two groups of species. Cattail, river bulrush, reed canary grass and creeping spike rush had higher transpiration rates than the other species (Figure 1). By the end of the season, differences in transpiration rates were no longer significant. These data are being analyzed using GIS in order to more accurately determine the evapotranspiration component of wetland water budgets.

BIOLOGICAL CONSIDERATIONS IN THE HYDROLOGICAL MODELING OF FRESHWATER MARSHES FOR WETLAND RESTORATION AND CREATION

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Louis Berger & Associates, Inc.
East Orange, New Jersey

Most wetland mitigation efforts that are targeted at the development of freshwater marshes should include a hydrologic budget of between 20-50 years duration (Figure 1). The purpose of such modeling is to ascertain not only whether the mitigation design has sufficient water to support the marsh, but from a biological viewpoint " Will there be too much water to sustain the mitigation target? Annual dominated vernal pools of California and playas of the Southern High Plains not only require seasonal ponding following winter rains, but require that the pools dry out before the selection pressures favor the development of a perennial marsh. Prairie pothole marshes do not experience annual drawdown, but rather drawdowns on intervals of between 5 and 20 years (van der Valk and Davis, 1978).

In classic marsh cycling, the marsh progresses from a developing drawdown phase (moist mudflats and shallow water, annual and perennial emergents) through several other phases until an open

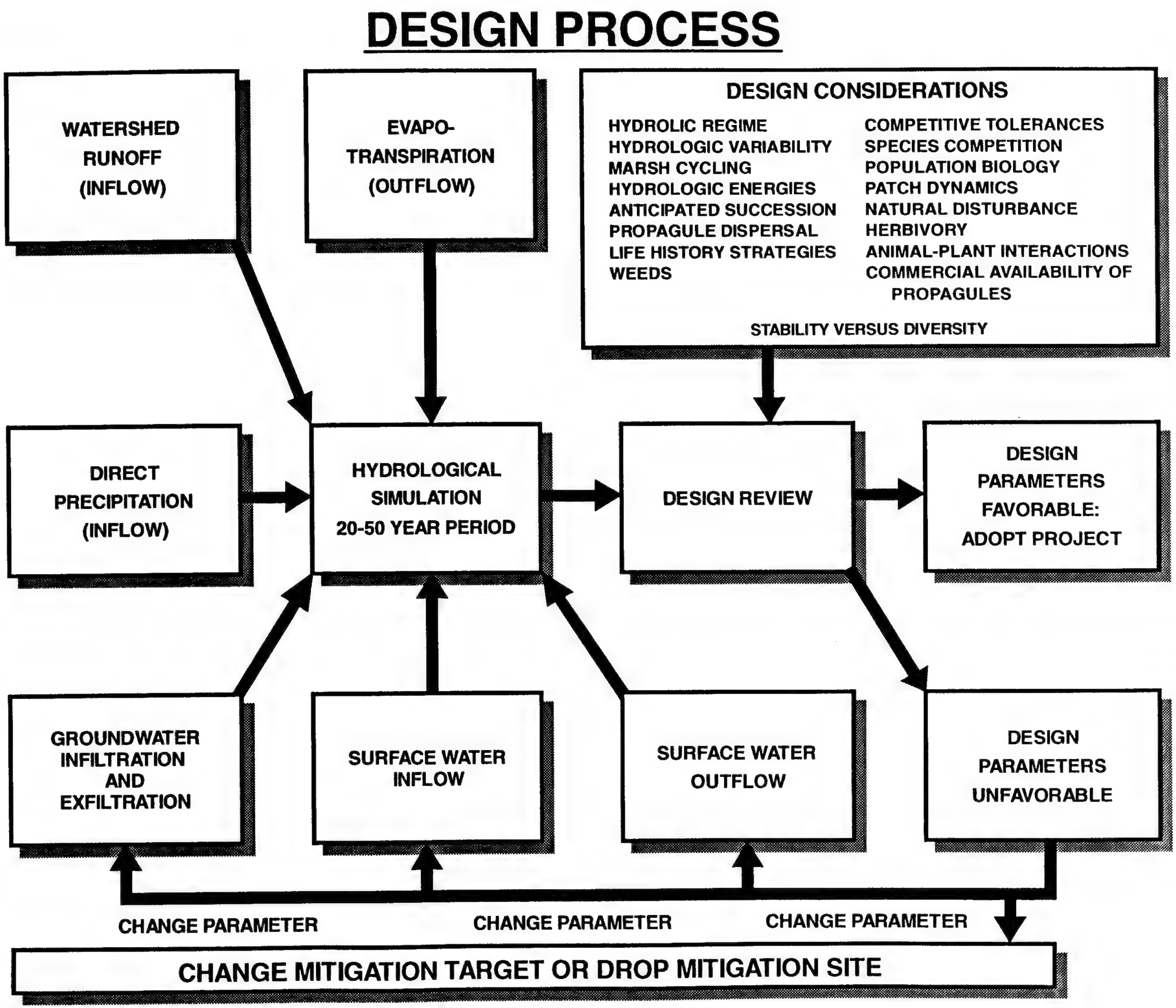

FIGURE 1: DESIGN PROCESS IN WETLAND MITIGATION

water phase lacking emergent cover is reached. This change in vegetation phases is often attributed to herbivory. The open water phase remains until a drought event results in the drawdown of the marsh. Following the return of the rains, the dormant seedbank germinates on the moist mudflats and in shallow water, re-establishing the emergent cover. As with many natural systems (Pickett and White, 1986), only with the occurrence of natural disturbance is the diversity and species richness maintained. The species that dominate the prairie potholes, for the most part, are the same species that dominate the eastern marshes. The entire species suite reported by van der Valk and Davis can be found east to the Atlantic Seaboard and its freshwater tidal marshes.

When designing non-tidal perennial marsh systems, it is recommended that the design allow for a drawdown of the shallowest segments of the emergent zone on a frequency of approximately six to ten years, so that the diversity of the system can be maintained. Additional biological and hydrological considerations must be factored into the decision of whether to accept a design (Figure 1). Estimates of evapotranspiration rates can be derived from a number of empirical equations (Jensen 1973). ASCE (1966) represents a field review and test of many of the equations. Kadlec (1989) discusses the use of Class A pan evaporation rates.

Once the hydrological model for a system has been developed, it is reviewed initially for the frequency and duration of drawdown events. Where the model indicates an unfavorable hydrological pattern, it may be possible to modify the design via changes in excavation depths (i.e., deeper into the water table), soil permeabilities, the frequency of surface water inputs, or changing the pool depths. Infrequently, it will be possible to change the watershed size.

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SPECTRAL REFLECTANCE PROPERTIES OF WETLAND PLANTS

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Introduction

Spectral reflectance characteristics of plants have been widely used by ecologists to diagnose physiological conditions and monitor succession. Reflectance spectra can be recorded by taking a photograph or by using a spectraradiometer to measure the wavelength response as a count of photons reflected (or absorbed) by an object. Photochemical pigments and leaf morphology play a significant role in plant spectral properties as a function of color, cuticle, shape, and intercellular spaces (Gates et al., 1965). Typically, photoreactions of plants represent an energy budget ranging in narrow bands from the blue (400 nanometers) to far-red and near infrared (710 to 780 nanometers) regions (Hale and Orcutt, 1987).

Stress Responses in Wetland Plants

Due to their position on the landscape and the frequency at which they are subjected to flooding, wetland plants differ from terrestrial plants physiologically and morphologically. In facultative species subjected to flooding, Koslowski and Pallardy (1979) discovered premature closing of leaf stomates, reducing stomatal conductance and translocation. Other documented flooding stress-related responses have been observed in wetland plants. Kawase (1981) found that in flood-intolerant species, ethylene production facilitated the collapse and disintegration of cell walls. Coutts and Phillipson (1978) describe the following symptoms associated with flooding stress in plants: chlorosis, drooping petioles, leaf epinasty, hypertrophy (swelling), and wilting. These responses facilitate physiological changes that may be detectable using spectraradiometry.

Experiment and Results

Recent experiments conducted by the Topographic Engineering Center and the Virginia Institute of Marine Science tested the hypothesis that wetland plants have unique spectral signatures

driven by stress and morphological characteristics that can be recorded using ground-level spectraradiometers in the .4 to .9μ bandpass. This hypothesis forms the basis for developing seasonal "wetland signatures," therefore allowing narrow-band image acquisition strategies to be developed. The objective would be to use narrow-band filtered imagery to more accurately classify wetland plant types and upland/wetland boundaries. The difference between broad-band and narrow-band spectral sensing is the amount of the spectrum being recorded at a given instance. In broad-band systems like conventional infrared photography, four 100 nanometer wide "channels" ranging from 400 to 800nm are recorded using chemical film emulsions. These broad 100nm windows can obscure details specific to vegetation biomass. Narrow-band spectral sensing offers control of wavelengths less than 25nm wide to examine fine details and features which are located at specific "response" wavelengths.

For the first part of this investigation, spectral differences for a monotypic stand of <u>Acer rubrum</u> growing within the floodplain of the Rappahannock River in central Virginia were observed. Trees occupying wetter hydric soil units with lower Redox potentials (-185mv) showed late maturation when compared with trees of the same stand continuum growing in "drier" soils with higher Redox potentials (+372mv) (Figure 1). Redox potential describes the reducing condition of soils whereby the availability of oxygen and nutrient availability is altered (Ponnamperuma, 1972). These results suggest that "spectral ecotypes" may exist and permit the differentiation of wet and dry sites when facultative plants are present. In a second part of the experiment, different spectral signatures for wetland plant canopies were recorded at Cedar Run marsh near Airlie, Virginia (Figure 2). Based on the resulting spectra, filters were adapted to a digital multiband camera and imaging missions were flown over the marsh. In comparison to convention imagery, the narrow-band imagery provided better characterization of wetland plant communities.

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Figure 1. Spectral first derivatives showing inhibition to move to longer wavelengths in stressed red maples.

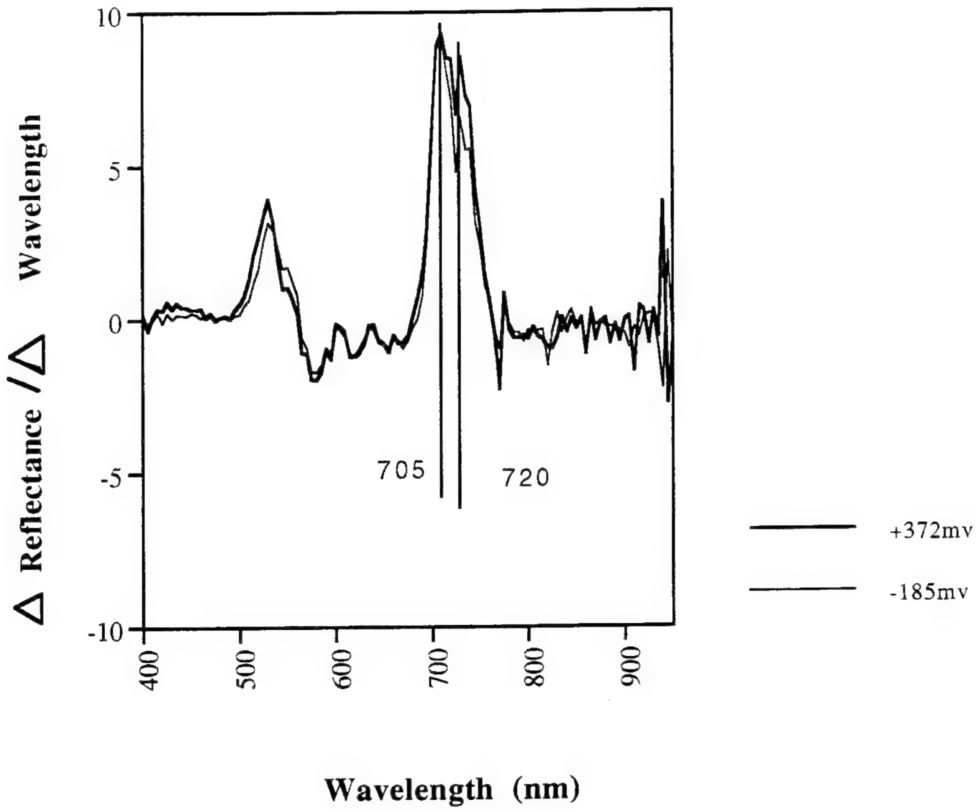
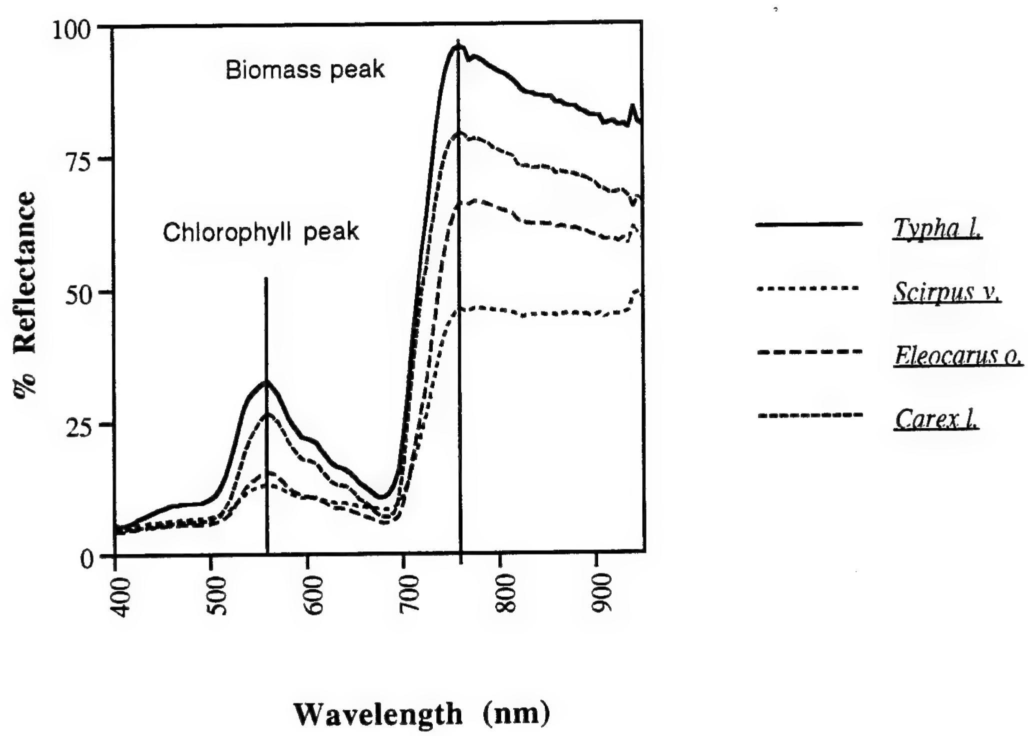


Figure 2. Spectral reflectance of various wetlands plants from Cedar Run Marsh. (Anderson and Perry unpublished data, 1994)



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ABOVEGROUND PRODUCTIVITY VALUES ACROSS A FLOODING GRADIENT IN A SOUTH CAROLINA COASTAL PLAIN FOREST

Marianne K. Burke & William H. Conner

Introduction

Although there is tremendous spatial variation in hydroperiods across floodplain systems, but there is a tendency to group various vegetational zones as floodplain communities. We address this heterogenieity issue with our ongoing study of aboveground production across a flooding gradient that includes a tupelo swamp, a transition to upland forest, and a hardwood and pine forest.

Methods

The study site is on the Donnelley Wildlife Management Area in the Ashepoo, Combahee, and Edisto (ACE) Rivers Basin of coastal South Carolina. Four distinct forest zones have developed along the hydrologic gradient flooded, wet transition, dry transition, and dry (Table 1).

Stemwood production was calculated using dbh and regression equations from Clark et al. (1985) to determine biomass differences between the beginning and end of 1994. For this determination, paired 20m x 25 m plots (500 m^2) were established in each zone. Within each plot, all trees $\geq$ 10cm diameter dbh were speciated, tagged and dbh was recorded. Tagged trees are measured annually at the end of the growing season.

Litter and seed production were estimated with the contents of ten 0.5 m^2 collectors (Phillips et al. in press) placed 20 m apart along the contour in each of zone. The collectors were installed in September of 1993 and were emptied at least monthly until September of 1994. Contents of each trap were refrigerated, sorted into leaf litter and seeds, and were dried and weighed.

Results and Discussion

The study area is a diverse habitat with sixteen tree species (Table 1). Much of this diversity can be attributed to the spatial variation in the hydroperiod: small differences in elevation have

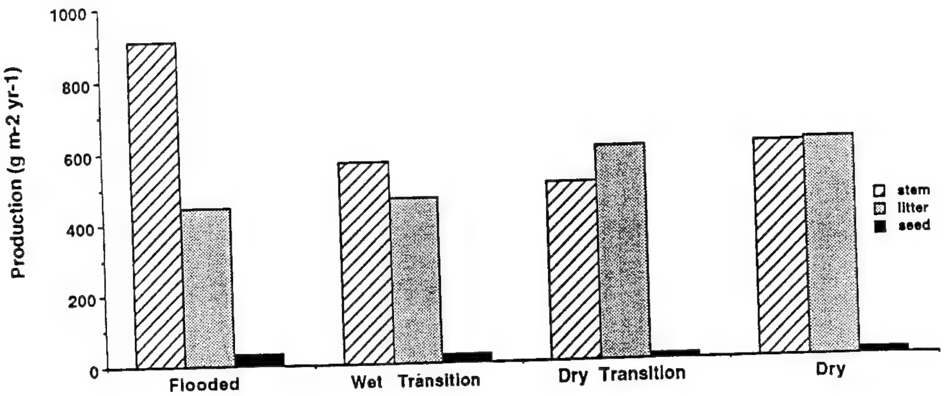

Figure 1. Stemwood, litter and seed production in the four vegetational zones.

Table 1. Density and percent of production for tree species in sample plots in the four vegatative communities.

SPECIES	FLOODED		WET TRANSITION		DRY TRANSITION		DRY	
	Density Stems/ Acre	% of Production	Density Stems/ Acre	% of Production	Density Stems/ Acre	% of Production	Density Stems/ Acres	% of Production
Green Ash	80	2	110	5				
Red Maple	10	0	140	22	10	0		
Swamp Blackgum	90	9	110	14				
Water Tupelo	350	89	50	13				
American Elm			10	4				
Sweetgum			260	41			100	6
Chinese tallow			40	1				
Laurel Oak					140	61		
Live Oak					10	1	20	7
Loblolly Pine					120	25	50	13
Spruce Pine					160	13	10	0
Black Oak							80	60
Flowering Dogwood							20	0
Mockernut Hickory							50	9
Shortleaf Pine							20	1
Water Oak							70	4

a great influence on the community species composition. No tree species are present in all four communities. Species present in two or three communities are important (% of density + % of production > 50) in only one of the communities.

Although production was expected to be highest in the transition communities, due to both an adequate moisture regime and soil aeration, production in the swamp was greater than in any of the other three communities (Figure 1). Lower production in the upland communities could be due to moisture stress as was observed in 1993, a relatively dry year. In contrast, stemwood production was least in the flooded zone and greatest in the dry zone in 1992, a wet year (Conner, unpublished data).

Leaf litter production was expected to comprise half of aboveground production, and this was true for all but the flooded community. Instead, litter production comprised only 1/3 of aboveground production in that community.

Seed fall was a minor component of aboveground production and was similar among zones. A difference among zones was the timing of seedfall: the flooded community had an abbreviated period of seedfall (Sept. to Dec.). The other communities had either a more extended period of seedfall (dry and dry transition) or two seasons of seed fall (wet transition).

The amount of biomass produced, the allocation among tissues, and the timing of production differ among the four zones on this flooding gradient. Because there is such high spatial variation in the production function along flooding gradients, it is inappropriate to group the various transitional forest zones as floodplain communities.

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THE GREENHOUSE EFFECT: TREE RING EVIDENCE FROM MILLENNIUM-OLD BALDCYPRESS IN SUBTROPICAL WETLANDS

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Atmospheric C02 has increased during the 1900s. Growth increases from C02 has been demonstrated for tree seedlings, however evidence from mature trees in natural settings is difficult to detect (Graybill and Idso 1993). Studies that have detected enhanced growth of mature trees in which C02 is a leading candidate cause are generally restricted to long-lived species at high elevations or latitudes (Graybill and Idso, 1993). However, Briffa (1991) reports large-scale increases in growth since the early-to-mid 20th century for long-lived conifers in western Europe at lower latitudes.

Recent research in southern Louisiana and Mississippi with old-growth baldcypress (Taxodium distichum) suggests initial evidence of C02-related tree growth enhancement for subtropical low-elevation inundated wetlands (Figure 1), Detection of the greenhouse effect in wetlands has important implications, because elevated C02 is projected to increase net ecosystem production, and recent experiments conducted across diverse wetland communities suggest that about 3 per cent of the daily net ecosystem production is emitted back to the atmosphere as methane (Whiting and Chanton, 1993).

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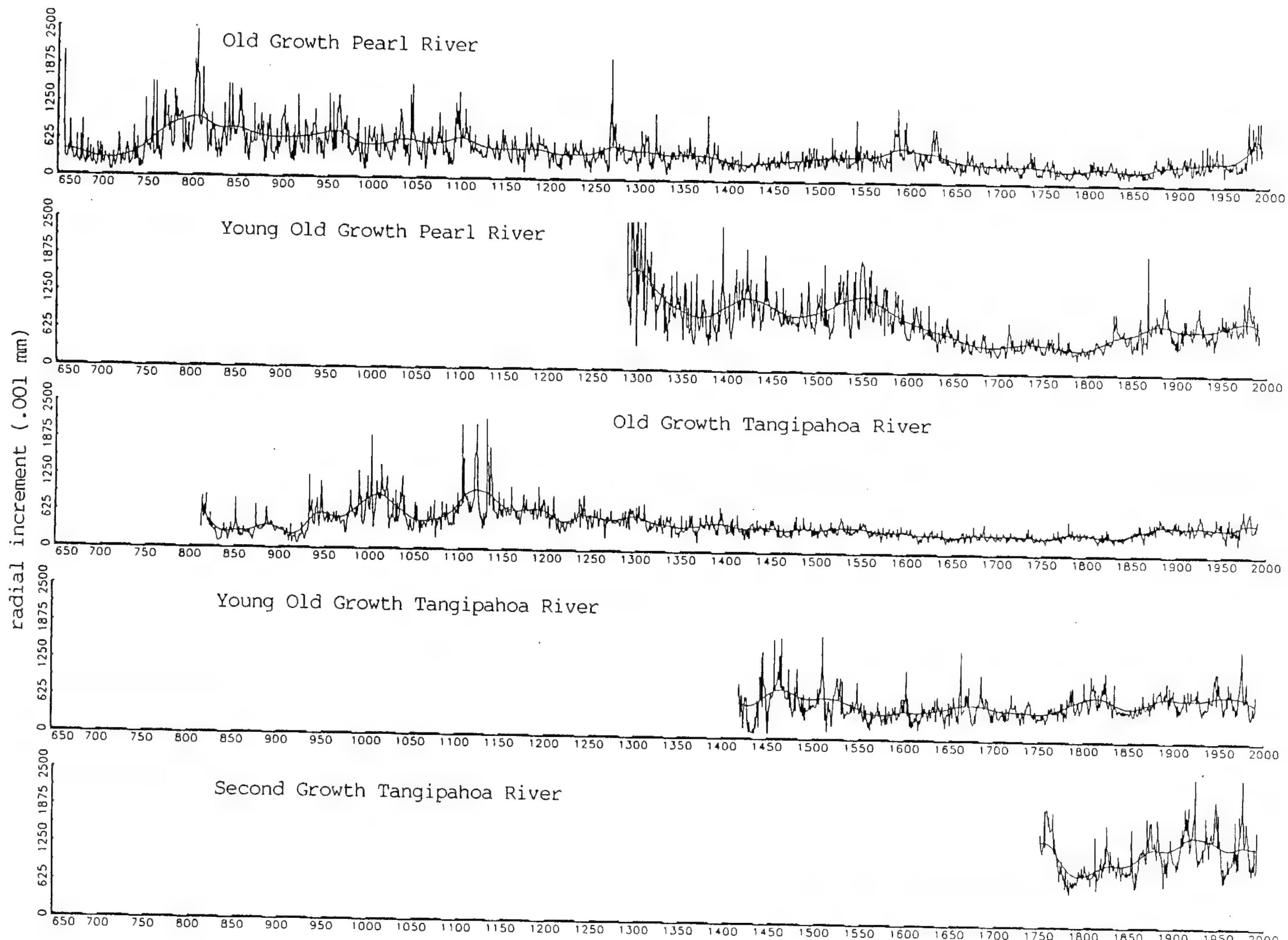

Fig. 1. Observed and smoothed radial increment of five classes of baldcypress. The smoothed curves emphasize growth trends of 30 or more years in duration.

SESSION SM2

STEWARDSHIP AND MANAGEMENT: MAPPING AND INVENTORY

Porter Reed Jr., Chair

WETLAND CLASSIFICATION OF BOTTOMLAND HARDWOOD AREA IN ARKANSAS USING REMOTE SENSING

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Wetlands are subject to numerous environmental influences, which tend to destabilize and bring about changes in the ecosystem. Wildlife Farms, Inc. is an undisturbed, privately owned, 1500-acre hunting refuge on the White River in Arkansas. It primarily consists of bottomland hardwood forest, with bordering loessial uplands. A vegetative map of this area was created using Landsat 5 satellite data. Satellite data from October and May of 1992 was used. Thirty meter plots along 2 transects were inventoried as to canopy make-up and density. Field data were compared with remotely sensed spectral signatures, to determine the degree of correlation. There appears to be a correlation between the degree of flooding and distribution of the trees in this area.

VEGETATION MAP OF THE BOTTOMLAND HARDWOODS OF THE BLACK SWAMP WILDLIFE MANAGEMENT AREA IN ARKANSAS

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Arkansas State University

The bottomland forests of the Black Swamp in Woodruff County, AR, were classified and mapped using Landsat 5 satellite images. The image was classified using a Bayesian Classification scheme. Forest communities distinguished by this analysis were ground-truthed for accuracy. Four distinct forest zones were classified and mapped. Oak forest was found and mapped in areas not subject to extensive flooding. Tupelo forest was found and mapped in areas subject to frequent flooding and subject to historical logging of baldcypress. Cypress-Tupelo forest was found and mapped in areas subject to extensive inundation and less subject to historical logging. Cypress forest was found in areas

less frequently flooded to areas of extensive inundation.

CLASSIFYING WETLANDS ALONG THE ENDICOTT ROAD

Christopher J. Herlugson
BP Exploration (Alaska) Inc.

H. Jiao
Aeromap U. S.

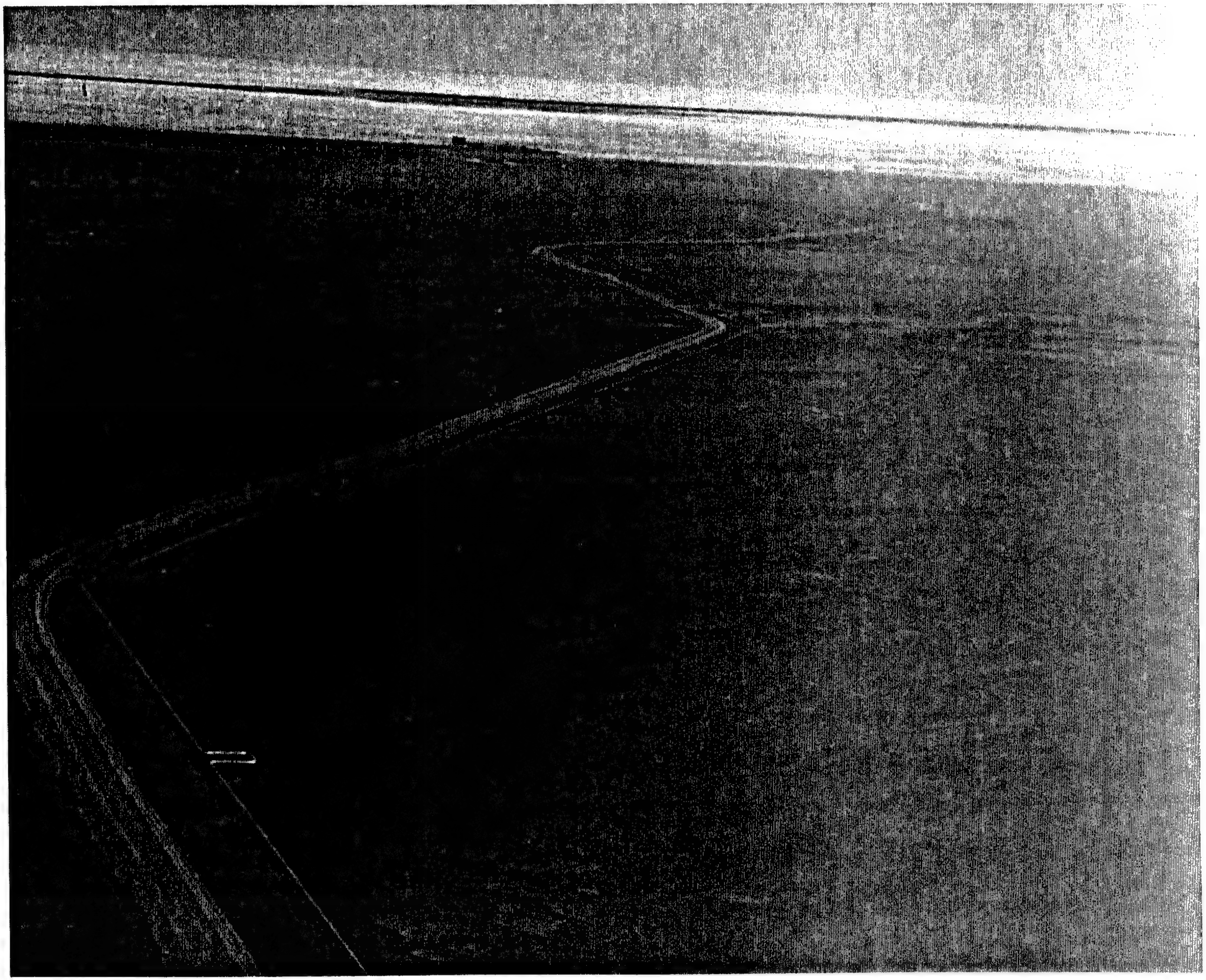
Steve Johnson and Curt Wilkinson
LGL Alaska Research

Lloyd H. Fanter
US Army Corps of Engineers, Alaska District
Anchorage, AK

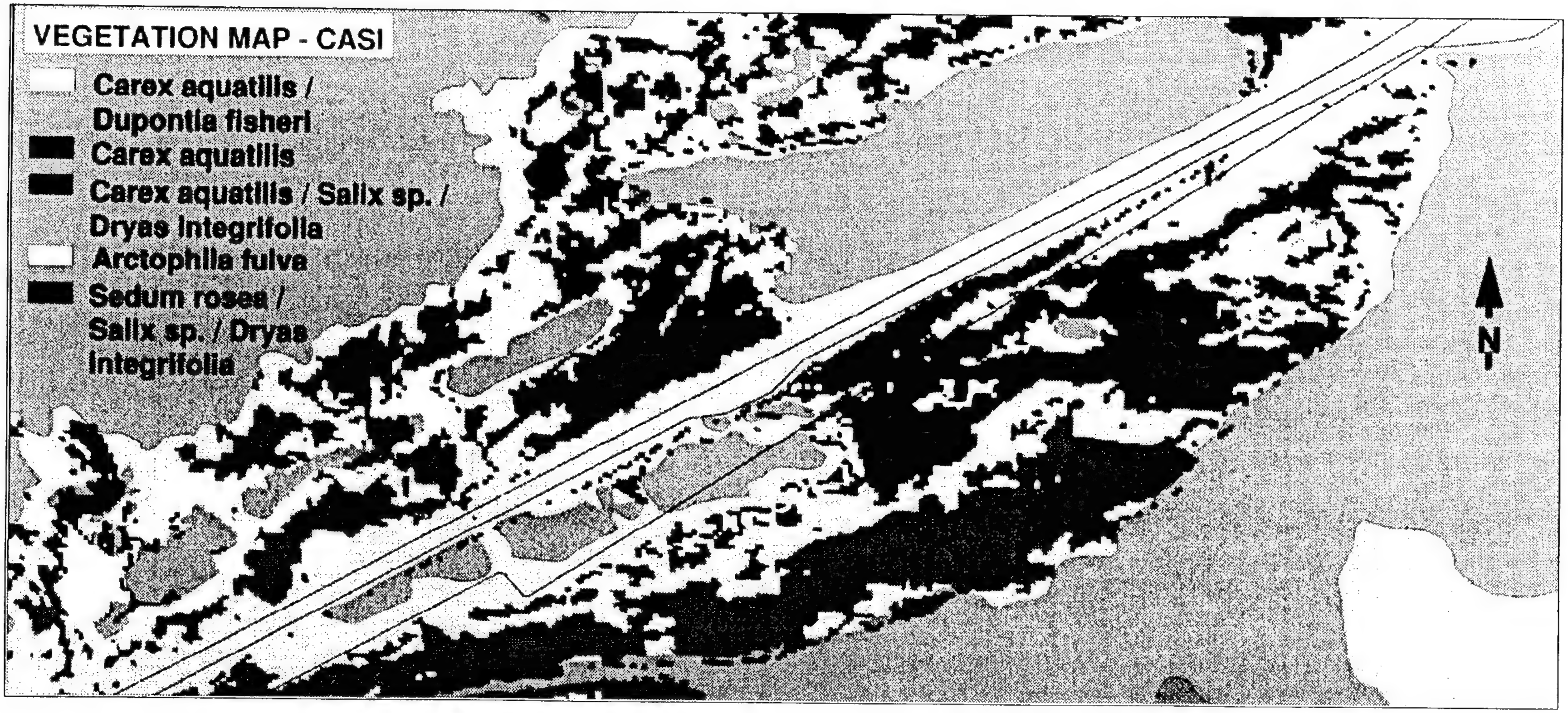
A combination of tools, including advanced airborne remote sensing, aerial photography, mapping technology, and ecological studies are used to classify wetlands on Alaska's North Slope. Built in 1984-85, the Endicott Development Project includes a gravel-fill road through wetlands used as brood-rearing habitat by Lesser Snow Geese (Chen caerulevcens caerulescens) that nest on Howe Island in the outer Sagavanirktok River delta, near Prudhoe Bay, Alaska. BP Exploration (Alaska) Inc. (BPX) worked with the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service (USFWS) to address their concerns that the road and subsequent use could adversely affect the snow goose population by altering brood-rearing habitat or changing the way the geese used it. Even though BPX avoided and minimized disturbances to high value wetlands along the Endicott road, two questions remained: What was the extent of habitat loss in the area? Have habitat losses had adverse effects on the snow goose population?

The study area included two traditional and contiguous snow goose brood-rearing areas, parts of which were covered with gravel by the Endicott road. BPX used Geographic Information System (GIS) technology to plot snow goose densities based on 4 years of monitoring data and also incorporated observations from population monitoring studies begun in 1980, four years prior to project construction. A combination of remote sensing (a multispectral scanner (CASI - compact airborne spectrographic imager)) and ground-truthing were used to identify vegetation classes. Color-coded maps that displayed locations of different vegetation classes and the intensity of use by snow geese were produced.

A habitat suitability index (HSI) using criteria developed by USFWS was used to determine habitat quality for impact assessment.



ENDICOTT ROAD AND CAUSEWAY 7/11/90


VEGETATION MAP - CASI
Carex aquatilis /
Dupontia fisheri
Carex aquatilis
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Sedum rosea /
Salix sp. / Dryas
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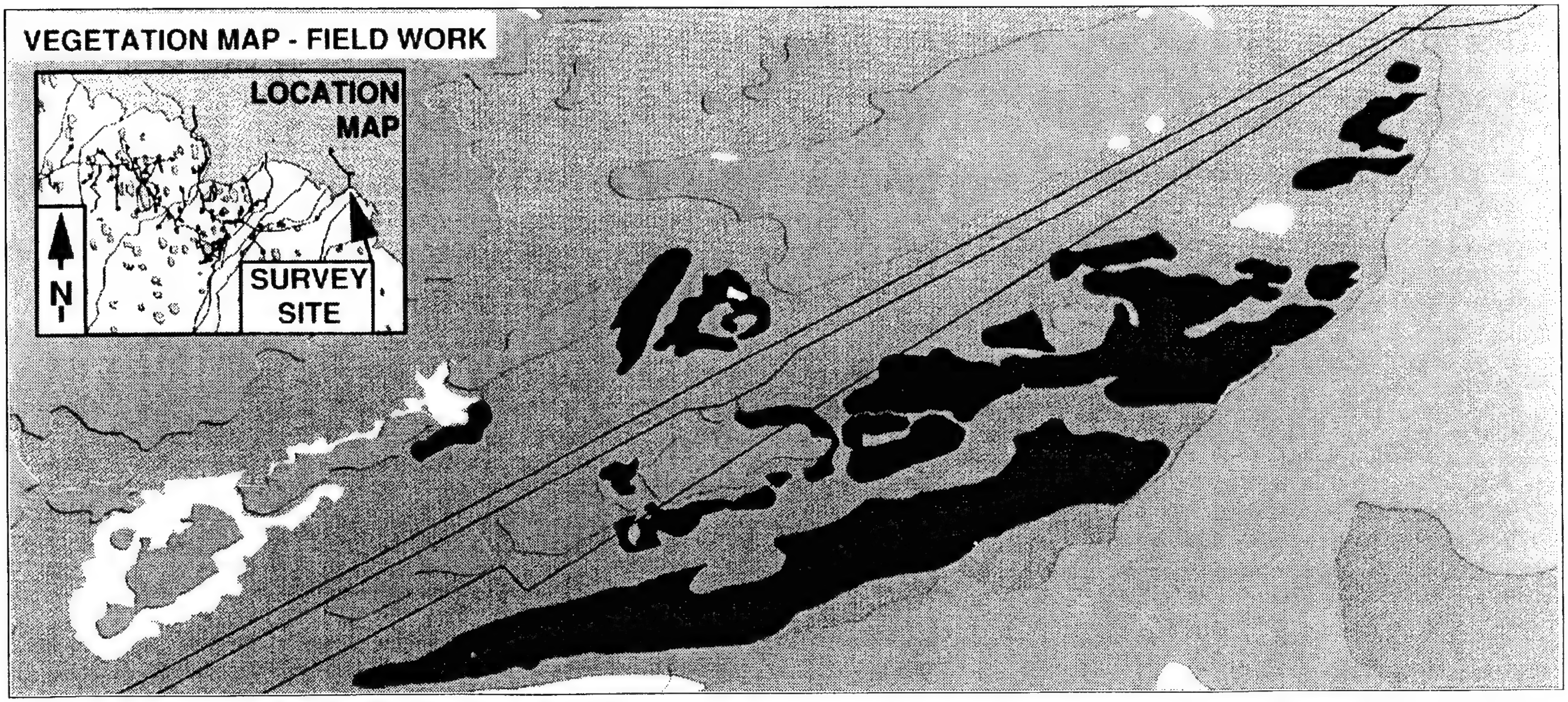
VEGETATION MAP - FIELD WORK
LOCATION MAP
SURVEY SITE
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The HSI for snow goose brood-rearing habitat was calculated by aggregating two suitability index scores, one for preferred vegetation and one for proximity to escape habitat. The vegetation index was based on characterizations of plant communities in areas where brood-rearing snow geese were known to forage. The escape index was based on distance to several lakes where geese escaped from terrestrial predators. BPX calculated HSI values for the road and non-road areas to estimate the amount and value of habitat lost.

Results

The direct impacts of the Endicott road were minimized during pre-project planning by selecting a road alignment that, to the extent practicable, avoided known high value habitats. Although use of snow goose brood rearing areas adjacent to the road was temporarily reduced during high traffic periods, there have been no documented adverse impacts from direct habitat loss resulting from gravel placement. Snow goose monitoring studies have shown no adverse impacts in terms of abundance, distribution, or habitat use patterns.

Advanced mapping and inventory technologies and resultant HSI models allowed BPX, USFWS and the Corps to work cooperatively in evaluating the amount and value of wetlands impacted by gravel fill, and to agree on an appropriate mitigation strategy.

Reference

LGL Alaska Research Associates, Inc. and Aeromap U.S., Inc. 1993.,Application ()f GIS, CASI and habitat suitability models to estimate loss of Snow Goose brood-rearing habitat. Prepared for BP Exploration (Alaska) Inc.

SESSION WP2

WATERSHED PLANNING II
R. Daniel Smith, Chair

ASSESSMENT OF THE CUMULATIVE IMPACTS OF SECTION 404 PERMITTING ON THE ECOLOGY OF THE SANTA MARGARITA, CA WATERSHED

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Introduction

The Santa Margarita River is one of the few remaining free-flowing rivers and provides one of the most expansive, unspoiled riparian habitats in Southern California. Rapid development of the upper watershed in the 1980s has been accompanied by disruption of riparian systems. To provide a framework for watershed planning, this study developed and implemented a methodology to assess the cumulative impacts of activities permitted under Section 404 of the CWA on the ecology of the Santa Margarita Watershed.

Assessment Methodology

The complexity of ecological systems compels the use of habitat composition as a surrogate for direct measurement of ecological function. The choice of surrogate measures is motivated by the need to balance ecological applicability against ease of measurement (Kentula et al., 1992). In this study, a semantic categorization was used to asses impacts based on six evaluation criteria (Table 1). Impacts were assessed by comparing conditions present at each project site before and after permit issuance. Each site was given a pre- and post- project rating of A, B, C, D, or E for each criterion, with "A" representing conditions similar to those at pristine reference sites. Impact scores between -4 and +4, were based on changes in the number of rating categories at each site. Project locations were color-coded based on impact and plotted on a watershed map using GIS.

Results

Section 404 permitting has failed to protect aquatic resources in the Santa Margarita Watershed. Approximately 74% of the acreage impacted has resulted in substantial adverse (scores of -4 or -3) or adverse impacts (scores of -2 or -1). Less than 1% of the affected acreage resulted in enhancement (scores of +1 or +2)

or substantial enhancement (scores of +3 or +4).

The greatest impacts were disruption of movement corridors (linear contiguity) and floodplain encroachment (adjacent habitats) (Figure 1). Degradation of corridors was amplified by the concentration of impacts near the urban centers, fragmenting two relatively undisturbed habitats and possibly hindering interaction and migration of faunal populations. The landscape position of impacts may have contributed to species becoming endangered, and may interfere with recovery of currently endangered species. Impacts to floodplains have resulted from channelization to support development. Constriction of streams within steep sided channels isolates them from adjacent uplands, limiting dynamic riparian processes such as overbank seed dispersal, and precluding movement of organisms between upland and riparian habitats (Harris and Gosselink, 1990).

Conclusion

The Santa Margarita Watershed is at a critical juncture. As growth of this region continues, the conflict between urban development and resource protection may escalate. Because a large portion of the watershed is relatively intact, the opportunity exists to develop a management plan which will allow development to proceed in a manner which is compatible with resource protection. This plan should incorporate the following: impacts should be considered in the context of past actions and landscape level processes; floodplain integrity should be maintained by explicitly considering impacts to riparian zones during permit review; and preservation of functionally valuable portions of the landscape should be accepted as mitigation for permitted impacts to less valuable portions of the landscape.

References

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Kentula, M.E., R.P. Brooks, S.E. Gwin, C.C. Holland, A.D. Sherman, and J.C. Sifneos. 1992. An Approach to Improving Decision Making in Wetland Restoration and Creation. United States Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

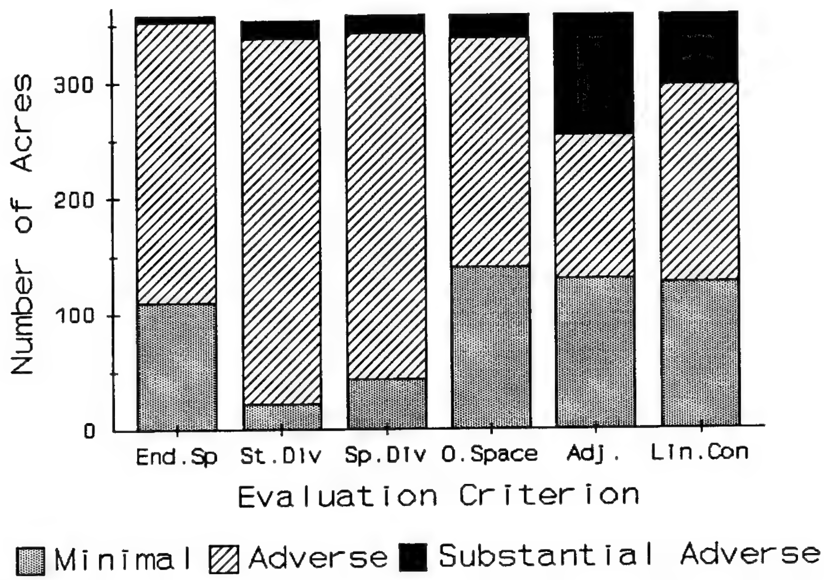

Figure 1: Number of Acres Receiving Each Impact Score by Criterion

Table 1: Sample Impact Evaluation

CRITERION	PRE PROJECT RANK	POST PROJECT RANK	IMPACT SCORE
Endangered Species Habitat	D	D	0
Structural Diversity of Habitats	C	D	-1
Spatial Diversity of Habitats	E	D	+1
Open Space Habitat	B	C	-1
Adjacent Habitats	B	E	-3
Linear Contiguity of Habitats	A	E	-4

OLD PRINCIPLES FOR A NEW WATERSHED PLANNING PARADIGM

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The new proponency for "watershed planning" appears to reflect a concept which, like its correlate "sustainable development", has been difficult to define in operational terms. Notwithstanding the absence of a well defined set of goals, principles and procedures for this new watershed planning paradigm, many planning efforts are underway purporting to be undertaking watershed planning to achieve sustainable development. Before watershed planning principles are applied to ecosystem restoration and, in particular, wetlands management, there needs to be a comprehensive development of sound principles and procedures that all agencies can use. We need a common frame of reference for decisionmaking - especially among federal regulatory and planning agencies.

It is the thesis of this inquiry that a watershed planning concept is evolving which is oriented towards maximizing a single goal- environmental protection - with little explicit consideration for equity, social well being or economic development. This contrasts with the sound body of planning principles that have evolved during the past 50 years. Furthermore, there exists no discernible central body of coherent and internally consistent planning and evaluation principles which has been developed akin to the Harvard Water Program's "principles and standards" for water resources planning (Maass, 1962). In reality, existing watershed planning "principles" are merely an extension of the eclectic body of environmental impact procedures that have proliferated over the past two decades, reflecting neither a coherent notion of planning objectives; nor a consistent set of evaluation principles; few agreed on normative decision rules; and a weak linkage to objective scientific analysis.

Added to this confusion, there already exist, three distinctly different evaluation frameworks, reflected in the regulatory agencies approach to planning <u>(prescriptive)</u> the traditional land use planning and coastal zone management models <u>(descriptive);</u> and the Federal water resources planning approaches <u>(indicative)</u>. The evolving watershed planning paradigm appears to be an ad hoc combination of the prescriptive regulatory approach tied to a vague articulation of the "NEPA process", which I will denote as the <u>"Proscriptive"</u> approach, i.e. managing by constraints rather than achieving objectives. Unfortunately the best features of a well-developed, comprehensive planning and evaluation philosophy inherent in federal water resources planning approaches have been ignored. These need to be introduced again into watershed planning and management.

Among the first steps that need to be considered is the development of a framework for Corps Civil Works planning purposes. What is needed is a watershed planning framework which looks first to the responsibilities and functions of the Corps of Engineers in a given watershed and attempts to coordinate, if not integrate, those roles. Hence, a first step is to assess the regulatory, planning and O&M activities and outputs of those respective programs and try to integrate the principles and procedures across programs. Corps regulatory program permit decisions should be consistent with overall watershed management objectives, as derived through a formal planning process. As a first priority, the Corps own evaluation and decisionmaking guidelines must be internally consistent.

The second step would be to integrate other Federal, state and local programs. The Soil Conservation Service (now called the Natural Resources and Conservation Service) has a statutory role in watershed planning, and our evaluation framework should be consistent with theirs. Fortunately, both the Corps and the former SCS have operated under the common planning principles and procedures of the Water Resources Council. There is a high degree of compatibility between the two agencies.

The Corps should focus on the current suite of planning- type activities that are already underway in many watersheds:

- Special Area Management Plans (SAMPS)
- Flood Plain Management Studies
- Ecosystem Management Planning
- Ecosystem Restoration Studies

The outcome of a proposed policy development effort would be a set of watershed planning guidelines which would serve as the basis for coordinating the numerous studies and efforts underway towards fulfilling a common set of watershed planning goals. The unpublished Level B river basin planning guidelines of the defunct Water Resources Council may serve as a useful start in the development of a coherent watershed planning framework for the Corps and other Federal agencies.

PENNSYLVANIA STATEWIDE COMPREHENSIVE WETLAND REPLACEMENT MONITORING PROGRAM

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In early 1993, the Pennsylvania Department of Transportation began a statewide comprehensive wetland replacement monitoring program. The program was developed for several purposes:

1. To address compliance with replacement wetland monitoring requirements and reporting in accordance with Section 404;

2. To develop a comprehensive, scientific, and reliable wetland monitoring system based on wetland functions and structure;

3. To aid the development of wetland replacement success criteria;

4. To aid in identifying successful and cost effective design and construction strategies based on field observations and data analysis;

5. To assess current replacement ratio requirements in relation to monitoring data results.

With one year of analysis completed under this first statewide program, trends and issues are already emerging which are shedding light on the validity of the concept of wetland replacement in general as well as specific design and construction strategies which can be implemented immediately for a higher success rate.

THE CONTRIBUTION OF WATERSHED PLANNING TO WETLAND MANAGEMENT

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The Clinton Administration's wetland policy statement supports wetland mitigation banking in the context of watershed planning. Other federal agencies and states have also advocated watershed planning as the framework for wetlands management. As part of the National Wetland Mitigation Banking Study being conducted by the US Army Corps of Engineers Institute for Water Resources, the authors focused on attempts to utilize watershed planning to facilitate wetlands management. This paper will report on several case studies of watershed/wetland plans now being developed across the country:

1. To identify common features in the approaches taken;

2. To identify the specific approaches taken to wetlands management in the plans; and

3. To evaluate the success of the plans in achieving wetlands management goals of no-net-loss and net-gain.

Lessons for other areas considering watershed/wetland plans will be drawn.

SESSION RE5

RESTORATION, PROTECTION, AND CREATION: BOTTOMLAND HARDWOOD RESTORATION IN THE SOUTHEASTERN COASTAL PLAINS

Dr. Kenneth W. McLeod, Chair

IS COMPETITION CONTROL NECESSARY FOR BOTTOMLAND RESTORATION?

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Early successional vegetation of disturbed wetlands provides cover and soil stabilization, but may limit successful establishment of woody species. To reduce this competition, vegetation control methods may be necessary to provide planted saplings an advantage over the competing vegetation.

The method of vegetation control may also influence the survival and growth of the saplings. Physically clearing the competing vegetation may allow sufficient light penetration for the sapling, whereas to also eliminate root competition, the vegetation may need to be chemically treated.

The size of the area that is treated may also influence survival and growth. Preparing planting strips may be all that is necessary, in contrast to treating a large area.

Thus, we examined the influence of chemical and physical controls of the competing vegetation on the growth and survival of four bottomland oak species (Quercus falcata var. pagodaefolia, Q. lyrata, Q. nuttallii and Q. phellos) and two swamp species (Nyssa aquatica and Taxodium distichum). These species were selected since their seed dispersal distances are short and it would be necessary to outplant saplings to accelerate succession. The site for the experiment was formerly a bottomland forest, but had been destroyed by thermal flooding and has been naturally revegetating for 8 years.

The hydrology of the site was distinctly different during the first two years of the study, creating very different stresses on the plantings. The first year (1993) was droughty throughout the growing season, with some relief starting in August. Spring of the second year (1994) was also droughty, but starting in late June precipitation was above normal causing three floods during the remainder of the growing season.

Table 1. Percent survival, as affected by treatment (C = Control; PR = Physical cleared, rows only; HR = Herbicided, rows only; PW = Physically cleared, whole plot; HW = Herbicided, whole plot).

SPECIES	YEAR	C	PR	HR	PW	HW
Nyssa aquatica	1993	90±4	93±4	90±7	87±6	83±0
	1994	87±8	67±12	77±7	73±11	67±7
Quercus lyrata	1993	83±7	90±7	93±4	97±3	100±0
	1994	93±4	90±4	90±4	100±0	97±3
Q. nuttallii	1993	77±4	90±4	90±10	87±3	94±4
	1994	67±7	83±5	83±9	80±8	80±6
Q. falcata	1993	93±4	93±4	93±4	97±3	100±0
var. pagodaefolia	1994	23±9	10±7	33±19	33±7	47±8
Q. phellos	1993	93±4	100±0	97±3	97±3	97±3
	1994	77±7	73±9	80±6	63±3	67±15
Taxodium distichum	1993	97±3	93±7	90±7	90±4	97±3
	1994	87±10	90±7	83±7	90±4	93±4

Mean survival ± 1 S.E. in October of 1993 and 1994. Sample size = 5.

Table 2. Percent survival, as affected by planting elevation, combining all competition control treatments.

	WETTEST			DRIEST
SPECIES	**(0 to +20cm)**	**(+20 to 30cm)**	**(+30 to 40cm)**	**(>+40cm)**
Nyssa aquatica	93/95[1] (41)	84/71 (51)	72/67 (42)	56/50 (16)
Quercus lyrata	96/95 (41)	95/96 (46)	88/92 (47)	68/94 (16)
Q. nuttallii	100/90 (40)	86/69 (49)	67/81 (42)	56/74 (19)
Q. falcata var. pagodaefolia	89/29 (31)	100/25 (55)	91/27 (49)	83/53 (15)
Q. phellos	95/68 (41)	98/65 (46)	93/73 (44)	92/95 (19)
Taxodium distichum	97/97 (38)	93/91 (47)	89/83 (47)	94/78 (18)

[1]Survival in October of 1993 and 1994. Sample size is shown in parenthesis.

Overall survival of each species following the first growing season exceeded 90% (Table 1). Survival was not significantly affected by the method of competition control during either of the first two growing seasons. Planting elevation (depth to the water table) influenced survival during the droughty first growing season with the best survival at the lower planting elevations (Table 2). During the second year, growing season floods have increased mortality of the less flood-tolerant species (Q. falcata var. pagodaefolia and Q. phellos).

Growth was also not significantly affected by method of competition control. Planting elevation did influence growth for N. aquatica, Q. falcata var. pagodaefolia, Q. phellos and T. distichum with the saplings planted at lower elevations having a larger increase in height. Quercus lyrata and Q. nuttallii saplings grew equally well at all elevations.

Competition control was not necessary for the establishment of woody species in this bottomland habitat. Relative elevation was an important factor in the success of most species. Selecting the most appropriate species for hydrologic conditions proved the most important factor in successful restoration of this disturbed bottomland. With species selected according to the relative elevation, a more species rich community could be successfully planted in existing early succession vegetation.

BOTTOMLAND RESTORATION IN THE SOUTHEASTERN COASTAL PLAIN

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Permanent, shallowly flooded sites are some of the more difficult habitats for successful forest restoration. In addition to the inundation, the substrate in these sites may range from clay bottoms to deep mucks in backwater pools and semi-solid, erodible sands in the braided channels of small streams. Restoration plans must address the range of problems dealing with the physical difficulties of working in this habitat with the biological limitation of flood-tolerance. There are very few species appropriate for this habitat and the method of planting and stock type will strongly influence survival. Over the past 3 years, several experiments, attempting to identify appropriate forest restoration techniques, have been conducted in the bottomland of a highly disturbed third order South Carolina coastal plain stream.

Few tree species can tolerate permanent inundation. Those

which can do not germinate and establish in standing water, but on mudflats under ideal climatic conditions. Therefore, attempting to establish two or three year old saplings in standing water was problematic. For these experiments, we selected three flood-tolerant species (Fraxinus pennsylvanica [green ash], Nyssa aquatica [water tupelo], Taxodium distichum [bald cypress]).

The first concern was successful establishment in areas with semi-solid sediments in backwater and slow-flowing streams. It was decided that we might be able to establish transplants by "planting" them on the sediment surface and allowing them to subsequently root into the substrate. This required a planting unit with a heavy base. Hence, commercial balled-and-burlapped saplings were obtained. Because of the high cost and logistic difficulties of handling this stock type, we decided to create a lower cost simulated balled-and-burlapped unit by placing a bareroot sapling in soil in a burlap bag, then planting this balled/bareroot unit as before. The responses of these stock types/planting units, planted in 30-60 cm of water, were contrasted with that of bareroot saplings.

Survival of bald cypress was 100% for all three planting units (commercial balled-and-burlapped, balled/bareroot, and bareroot). Commercially balled-and-burlapped water tupelo were not available for comparison, but survival of the balled/bareroot planting unit was 78%, less than the survival of bareroot plantings (85%). Survival of green ash balled-and-burlapped units was 100%, much greater than that for the balled/bareroot (53%) or plain bareroot (5%) units.

Bareroot saplings were also planted in a shallower depth (0-30 cm of water). Survival of bald cypress and water tupelo saplings did not differ between the two depths, but green ash saplings in the deeper depth had 40% survival compared to 88% survival in the shallow depth after the first growing season. The differences were even greater after two growing seasons.

The next concern was how to establish saplings in inundated muck soils. Here the problem was not as much getting the root system in the sediment, but rather doing so without "j"-rooting the sapling or greatly disturbing the soil by attempting to get a large root system in the sediment. This latter problem affects the minimal sediment structure and its physical stability, which will subsequently be required to support the plantings. These problems were addressed by pruning the root systems by varying amounts, such that they were strong enough to be simply inserted into the soft sediments and staking to provide stability until new root growth could occur.

Green ash was inappropriate for this muck soil site with survival below 20%, regardless of root pruning technique. Cuttings of water tupelo and bald cypress also had poor survival. But

survival of these two species when severely root pruned (leaving only a 23 cm long tap root) or moderately root pruned (creating a 23 cm diameter ball of roots) was greater than 80% after two growing seasons.

Another very important factor in revegetating shallowly flooded areas was protection from herbivores. These results were from studies in which the plantings were protected by tree shelters. Complementary studies indicated that herbivory reduced overall height and increased mortality tremendously. The species differed greatly in their capacity to tolerate herbivory and in their ability to resprout following cutting.

Thus, there were several methods feasible to establish tree saplings in permanent flooded conditions. Bald cypress survival was excellent when planted as balled-and-burlapped, balled/bareroot or bareroot in sites with as least semi-solid bottom sediments or as moderately or severely root pruned bareroot stock in muck soils. The same results was true for water tupelo, except that we were unable to obtain balled-and-burlapped stock to verify this result. In inundated muck soil sites, green ash was not an appropriate species, but could be successfully planted in flooded sites with semi-solid sediments by using balled-and- burlapped stock in deep water or bareroot stock in shallow water.

RESTORATION OF A FORESTED WETLAND ECOSYSTEM IN A THERMALLY IMPACTED STREAM CORRIDOR

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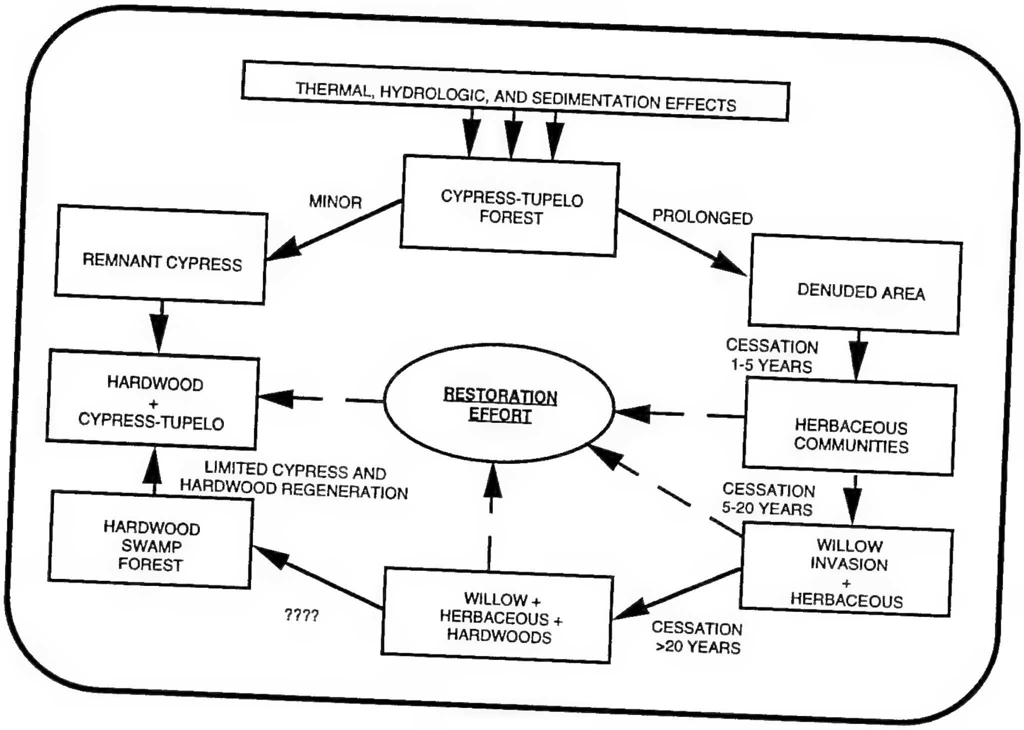
The Savannah River Swamp is a 3020 ha forested wetland on the floodplain of the Savannah River and is located on the Department of Energy's Savannah River Site (SRS) near Aiken, SC. Historically the swamp consisted of approximately 50% bald cypress-water tupelo stands, 40% mixed bottomland hardwood stands, and 10% shrub, marsh, and open water. Creek corridors were typical of Southeastern bottomland hardwood forests. The hydrology was controlled by flooding of the Savannah River and by flow from four creeks that drain into the swamp prior to flow into the Savannah River. Upstream dams have caused some alteration of the water levels and

timing of flooding within the floodplain.

Major impacts to the swamp hydrology occurred with the completion of the production reactors and one coal-fired powerhouse at the SRS in the early 1950's. Water was pumped from the Savannah River, through secondary heat exchangers of the reactors, and discharged into three of the tributary streams that flow into the swamp. Flow in one of the tributaries, Pen Branch, was typically 10-20 cfs prior to reactor pumping and 400 cfs during pumping. This continued from 1954 to 1988 at various levels. The sustained increases in water volume resulted in overflow of the original stream banks and the creation of additional floodplains. Accompanying this was considerable erosion of the original stream corridor and deposition of a deep silt layer on the newly formed delta. Heated water was discharged directly into Pen Branch and water temperature in the stream often exceeded 50 degrees C. The nearly continuous flooding of the swamp, the thermal load of the water, and the heavy silting resulted in complete mortality of the original vegetation in large areas of the floodplain.

In the years since pumping was reduced, early succession has begun in some affected areas (see figure). Most of this has been herbs, grasses, and shrubs. Areas that have seedlings are generally willow thickets that support a lower diversity of wildlife. No volunteer seedlings of heavy-seeded hardwoods or cypress have been found in the corridor areas. Research has been ongoing to determine methods to reintroduce tree species characteristic of more mature forested wetlands. The goal of the restoration is to create structural and biological diversity in the forest canopy by establishing a mix of species typically present in riparian and wetland forests of the area. It is anticipated that the successful restoration will require a combination of two approaches. They are the rehabilitation of the Pen Branch corridor and delta by natural succession and the reforestation of the corridor and delta by planting. Areas that are identified to have sufficient natural regeneration of desired species are being allowed to evolve naturally to restored condition. These areas appear to be confined to the lower delta and upper corridor regions. Areas that are not naturally reforesting are being aided by planting seedlings of desired late successional species and densities to speed the mitigation process. Silvicultural site preparation has depended on the successional stage of the planting area. Species selection and compositional mix are being altered based on the current and expected hydrological regimes that the reforestation areas will be experiencing.

The process is expected to be a decade-long project. Success criteria for evaluating the establishment and functionality of the forested wetlands will be established based on the monitoring of the project.


THERMAL, HYDROLOGIC, AND SEDIMENTATION EFFECTS
CYPRESS-TUPELO FOREST
MINOR
PROLONGED
REMNANT CYPRESS
DENUDED AREA
CESSATION 1-5 YEARS
HARDWOOD + CYPRESS-TUPELO
RESTORATION EFFORT
HERBACEOUS COMMUNITIES
LIMITED CYPRESS AND HARDWOOD REGENERATION
CESSATION 5-20 YEARS
HARDWOOD SWAMP FOREST
WILLOW INVASION + HERBACEOUS
????
WILLOW + HERBACEOUS + HARDWOODS
CESSATION >20 YEARS

SESSION RE6

RESTORATION, PROTECTION, AND CREATION:
WETLAND RESTORATION AT VANDENBERG AFB:
CONSTRUCTION AND HYDROLOGIC MONOTORING

Edward Mullen, Chair

CREATION AND BIOLOGICAL MONITORING OF COASTAL DUNE SWALE WETLANDS AT VANDENBERG AIR FORCE BASE, CALIFORNIA

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Eight acres of dune swale wetlands have been created by excavating to groundwater at two sites in the stabilized dune system at San Antonio Terrace, Vandenberg Air Force Base (VAFB), California, as mitigation for impacts to wetlands caused by construction of the Peacekeeper in Rail Garrison missile test program. Design of the wetlands and of the monitoring program was developed by biologists and managers from the USAF Ballistic Missile Organization and its contractors with the assistance and oversight of a biological mitigation committee composed of scientists from universities, from federal and state agencies, and from the environmental management office at VAFB. Key aspects of the design include use of salvaged topsoil and seedbank from nearby wetlands that had been filled during project construction, and preparation of separate mixes of seed for wetland bottoms, margins, and upland slopes from seed collected entirely from the local San Antonio Terrace sand dune area (Tables 1 and 2).

After four years of a five-year vegetation and wildlife

Table 1

PLANTING ZONES FOR SPECIES SEEDED AT THE CREATION SITES

	Berm	*Upper Margin*	*Lower Margin*	*Bottom*
Baccharis douglasii (Douglas' baccharis)	x	x	x	
Leymus (=Elymus) triticoides (Alkali ryegrass)	*			
Juncus effusus var. *brunneus* (Common bog rush)			x	x
Juncus lesueurii (Dune rush)	x	x		
Juncus textilis (Basket rush)			x	
Myrica californica (California wax-myrtle)	x	x	x	
Polygonum punctatum (Water smartweed)			x	
Rhamnus californica subsp. *californica* (California coffeeberry)	x	x		
Rubus ursinus (Pacific blackberry)	x	x	x	
Rumex salicifolius var. *salicifolius* (Willow dock)	*			
Scirpus californicus (California bulrush)				x
Scrophularia atrata (Black-flowered figwort)	x	x		
Typha latifolia (Broad-leaved cattail)				x

Table 2

UPLAND SEED MIX USED ON SLOPES AND BUFFERS

Scientific Name	*Common Name*
Artemisia californica	Coastal sagebrush
Camissonia cheiranthifolia subsp. *cheiranthifolia*	Beach primrose
Carex pansa	Sand dune sedge
Eriastrum densifolium subsp. *densifolium*	Mesa phlox
Ericameria ericoides subsp. *ericoides*	Mock heather
Erigonum parvifolium var. *parvifolium*	Dune buckwheat
Lessingia (=Corethrogyne) filaginifolia	Common corethrogyne
Lotus scoparius var. *scoparius*	Deer weed
Monardella frutescens	Dune mint
Mucronea (=Chorizanthe) californica	California spine-flower
Senecio blochmaniae	Blochman's butterweed

monitoring program, outstanding development of wetland vegetation and wildlife habitat has been documented. To verify that the created wetlands exhibit physical and biological attributes, functions, values, and permanence comparable to natural dune swale wetlands, we have concurrently monitored and compared the created wetland sites with six reference wetlands representing a range of nearby natural dune swale wetland types. Results, summarized in companion presentations by Kensok et al., Mullen et al., and Parikh et al. appear to validate this approach to dune swale wetland creation and monitoring.

By the fourth year willow saplings had grown to 10-20 feet in height and wax-myrtles exceeded 6 feet. Wetland margins and buffers were densely vegetated with a variety of emergent wetland species (including all of the wetland species included in the seed mix). All but the deepest permanently flooded areas had a dense cover of emergents, especially cattails and bulrushes. The deepest areas are open water utilized extensively by ducks, coots, and grebes which feed on submerged aquatic plants, invertebrates and amphibian larvae. These deep areas are designed to serve as refuges for wetland species during extended droughts. The created sites are used extensively by wildlife, including breeding and wintering birds, reptiles and amphibians (including the California red-legged frog, proposed for federal listing under the Endangered Species Act), and a wide variety of mammals. Success is evaluated with respect to a detailed set of performance criteria developed at the beginning of the project.

THE COASTAL DUNE WETLANDS CREATION PROGRAM AT VANDENBERG AIR FORCE BASE: CONSTRUCTION AND HYDROLOGIC MONITORING

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In 1990, the fifth year of a drought, eight acres of wetland habitat were created on Vandenberg Air Force Base, California by excavating to groundwater. The wetlands were created as a condition to the U.S. Air Force for a nationwide general permit issued by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act to mitigate the filling of wetlands during construction of test facilities for the Peacekeeper Rail Garrison and Small ICBM missile test programs on the San Antonio Terrace portion of the base. Two wetland creation sites were selected on the San Antonio Terrace based on several criteria; among them a shallow water table, a degree of biological degradation, absence of significant plant communities, and accessibility.

Topsoil from previously filled wetlands had been salvaged and stockpiled for reuse on the created wetlands. The top 4 feet of soil from one of the created wetland sites was also stockpiled for use on the slopes of both created wetlands. Seeds of upland and wetland vegetation were hand collected from San Antonio Terrace to ensure genetic integrity and adaptability to local conditions.

The excavation of the first wetland was completed in late November 1990. Wetland and upland topsoil was then spread on the bottom and slopes, respectively. At that point there was standing water over 1/3 to 1/2 of the bottom area plus in two 1/8-acre subwetlands which had been excavated 2 feet deeper. The water level in the wetland continued to rise, due to a combination of rain and release of groundwater from the soil. By the end of January 1991 nearly the entire bottom was under water.

The second site was different from the first in many ways; consequently, construction of this wetland posed different challenges. Water appeared much sooner during excavation of the second wetland. The groundwater generally followed the topography and in some areas was confined under clay layers, so it had some head. Therefore, the groundwater bubbled up from small springs that were uncovered in various locations during excavation. The topography varied in elevation by 20 feet from one end to the other, so surface water accumulated at the toe. We constructed three sand berms across the wetland to spread the water more evenly along its length and retain more water in the upper areas.

The water level of the second wetland steadily increased and when excavation was completed in December 1990, the lower two areas were covered with water and there was some ponded water in the upper two areas. Native wetland topsoil was spread on the margins and berms, and upland topsoil was spread on the slopes. The entire site was then seeded with native seed mixes.

Both prior to and after creation of the wetlands, the hydrology of the San Antonio Terrace has been studied by analyzing precipitation, evaporation, and groundwater level. We presently have groundwater monitoring wells at 58 locations on the Terrace, 44 of which are in or near the two created wetlands and six natural wetlands which we are monitoring for comparison purposes. Since March 1991, wells at 52 locations have been continuously monitored (3 were dry in March 1991 and 3 are inaccessible now). The groundwater level has risen and fallen seasonally, but has trended upward since monitoring began (at the end of California's 5-year drought). The average net change in groundwater level between March 1991 and January 1995 has been +53 inches. Hydrologic monitoring will be continued throughout the 5-year biological monitoring period, which ends in December 1995.

WILDLIFE MONITORING OF CREATED DUNE SWALE WETLANDS ON THE SAN ANTONIO TERRACE, VANDENBERG AIR FORCE BASE, CA

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This paper presents the results of four years of wildlife monitoring of dune swale wetlands created to mitigate impacts of Air Force test facilities constructed on the San Antonio Terrace. The mitigation program includes the creation and monitoring of two 4-acre wetlands in a sensitive coastal dune ecosystem. The wildlife monitoring project, in conjunction with vegetation monitoring and hydrologic monitoring, was designed to assess the "success" of the wetland creation project in terms of providing functional habitat values similar to natural dune swale wetlands on the San Antonio Terrace. The program involves 5 years of seasonal wildlife monitoring at the two created wetland sites and six natural "reference wetlands." The reference wetlands were chosen to represent the range of wetland types found on the terrace. A summary of the habitat characteristics (the created and reference wetlands) is presented in Table 1.

Surveys were designed to characterize and compare the wildlife communities utilizing the created wetlands with those utilizing the reference wetlands in an ecologically meaningful way. Comparisons focus on birds as indicators of wetland status and integrators of ecological information, but the presence of invertebrates, amphibians, reptiles, and mammals were also at least qualitatively assessed. Each wetland site (created and reference) was surveyed for birds four times per season. Individual survey duration was for 1-1/2 hours. Mammals were sampled by live trapping and track and sign surveys; reptiles and amphibians were surveyed by observation of individuals or sign and by pitfall live-trapping. Aquatic invertebrates were sampled by dipnetting various habitats in shallow water and by close inspection of rocks and emergent vegetation.

Data was collected and analyzed for similarities and differences between the created and reference wetlands in species presence, abundance, and diversity. For the analysis, bird species were grouped into guilds, which are defined as groups of avian species that have similar ecological requirements. It was quickly realized that the wetter created wetlands supported more bird species associated with open water (ducks and shorebirds) than the drier, more overgrown reference wetlands. As vegetation developed at the created sites and the reference wetlands recovered from several successive drought years, the wetlands have consistently become more similar to each other in species composition. The high plant productivity and abundant invertebrate population at the new

Table 1. Summary of Habitat Characteristics of Monitored Created and Reference Wetlands

Reference Wetland	*Open Water*	*Low Marsh*	*High Marsh*	*Wetland Scrub*	*Willow Woodland*	*Oak Woodland*	*Transitional Dune Swale*	*Comments*
1		x	x (remnant)	x	x			Small, diverse wetland supporting a range of habitats including wet marsh and open sand.
2			x	x	x		x	Dry, transitional wetland dominated by scrubby vegetation and willow woodland.
3	x	x	x		x	x	x	Bowl-shaped wetland with minimal standing water. Unique because supports substantial oak woodland habitat that is otherwise rare on the Terrace.
4		x	x	x	x			Long narrow wetland with a large area of standing water that has developed since a protracted pre-project drought ended in 1991.
5		x	x		x			Large mature wetland with a deep bulrush/cattail marsh and large dense willow woodland.
6			x	x			x	Dry transitional wetland lacking willow woodland.
Live Oak Springs (created wetland)	x	x	x		x		x	Consists of three regions of different elevations; the highest level supports patchy low marsh, high marsh, and willow woodland vegetation; the middle level supports dense low marsh vegetation; and the low area supports open water with aquatic vegetation.
Wildflower Wetland (created wetland)	x	x					x	Oval-shaped wetland with a relatively flat bottom. Thick stands of cattails grow in the shallow water along the borders and extensive stands of bulrushes carpet the majority of the interior of the wetland. Open water remains only in the three deepest portions of the wetland.

Notes:
- Open Water: Exposed ponded water.
- Low Marsh: Occurs in wetlands with some ponded water and includes obligate wetland plant species such as bulrush and cattail.
- High Marsh: Composed largely of common bog rush.
- Wetland Scrub: Composed of coyote brush with an understory of field sedge and ryegrass.
- Willow Woodland: Dense willow woodland with a species-rich understory.
- Oak Woodland: California coast live oak overstory and an understory of basket rush.
- Transitional Dune Swale: Dominant species include both wetland and upland plant species.

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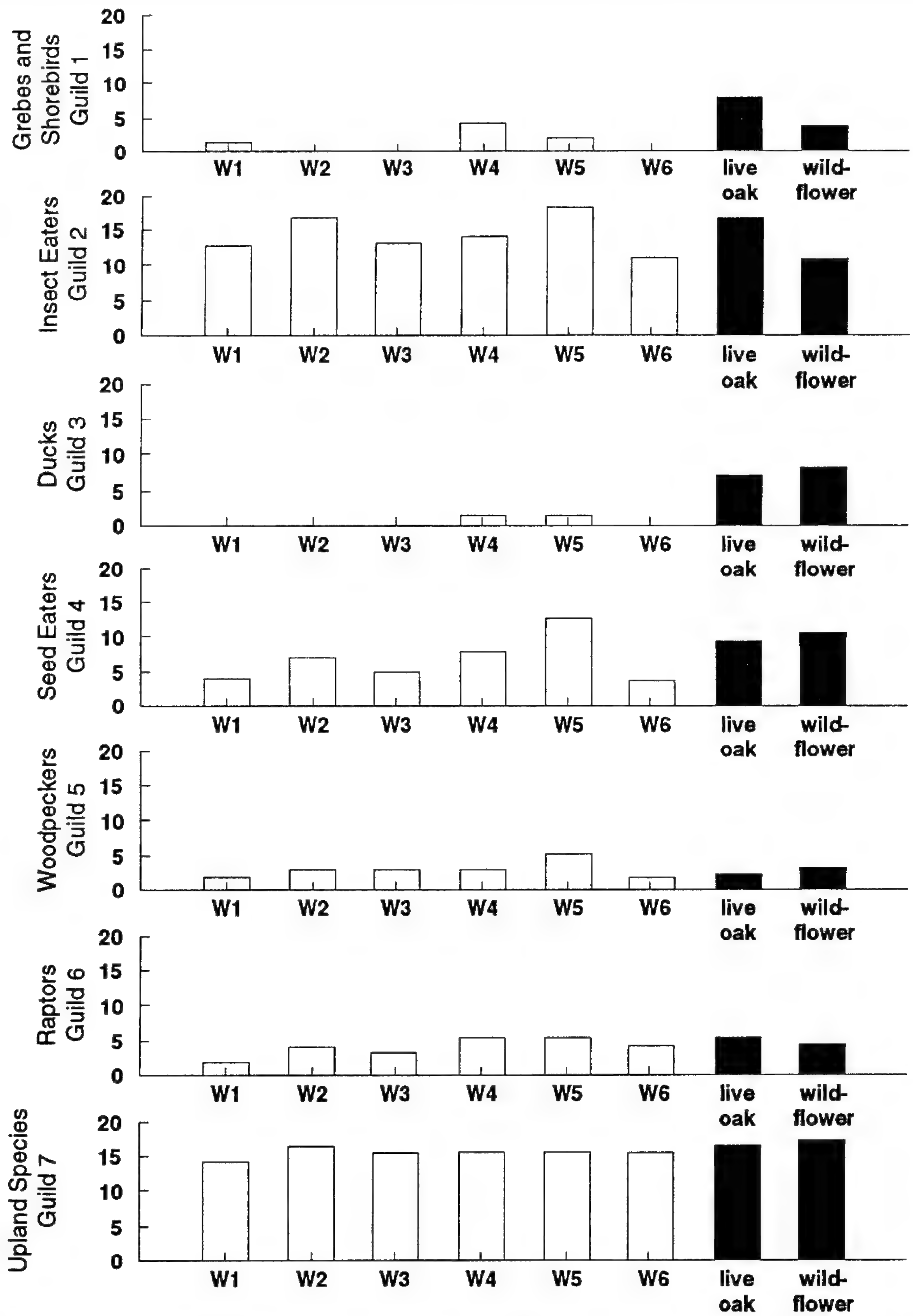

Species Number by Wetland for Each Guild Total 1994

Figure 1

wetlands support a high diversity of birds, mammals, reptiles, and amphibians. In the fourth year of existence, the created wetlands surpass or fit within the range of species abundances, numbers, and diversities found at the reference wetlands (Figure 1).

VEGETATION MONITORING OF CREATED WETLAND SITES ON THE SAN ANTONIO TERRACE, VANDENBERG AIR FORCE BASE, CALIFORNIA

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Introduction

An ongoing mitigation program on the San Antonio Terrace at Vandenberg AFB includes the creation of two wetlands followed by five years of monitoring to compare vegetation development at the created wetland sites and six mature representative wetlands on the Terrace (U.S. Air Force, 1994). The approach taken to monitoring has two primary objectives: 1) to document descriptively the development of the created sites over time, and 2) to assess analytically the similarities between the created wetlands and natural wetlands. No absolute evaluation criteria have been established, rather the success of the project is being evaluated relative to its unique ecosystem context, based on the direct comparison of data collected in the created wetland sites and the reference wetlands.

Methods

Transects and plots were established for long-term vegetation monitoring in all the wetlands. Data recorded include percent cover for various vegetation categories and for individual species, and topographical elevations and water depths along the transects. Topographic profiles and species distributions were mapped for the ten species with highest total cover values along each transect. From raw data collected from each plot, three species measures were computed: the number of species by plot and wetland (species richness); the area per m^2 covered by each species (species cover); and the percent occurrence of each species in all plots sampled (species frequency). Statistical comparisons of these vegetation parameters were made using analysis of variance (ANOVA), hierarchical clustering, and multidimensional scaling (MDS) to explore patterns of similarity and dissimilarity between the created and reference wetland sites.

Results and Discussion

The transect profiles portray graphically the differences in species distributions at various topographical elevations in the wetland sites. In this paper, we present a representative transect profile illustrating changes between years 1 and 4 of the monitoring program (Figure 1).

Species richness values are much higher at the created wetland sites than in the reference wetlands. ANOVA results indicated a significant difference in mean richness among wetlands in 1991 ($F(7,77) = 4.82$, $p < 0.001$), but by 1994, this difference was no longer significant ($p > 0.05$). As vegetation stabilizes over the years at the created sites, with the development of more perennial species, it is anticipated that richness will decrease in the created wetlands.

Of the three vegetation parameters, the species cover data initially showed and continue to demonstrate the highest degree of similarity between the created and reference sites. In general, the MDS configurations of both years show the distinction between the wetter and drier wetlands, with the created sites more similar to the wetter reference wetlands (Figure 2a). Overall vegetation cover has become increasingly similar between the created and reference wetlands over the four-year monitoring period.

Compared to cover values, species frequencies were distinctly different in 1991 between the created and reference wetlands. During the four years of monitoring, frequencies of the same species have become more similar between the created and reference wetlands (Figure 2b). The created sites continue to resemble each other closely, an expected result since both sites received the same seed mixes and similar topsoils. With time, it is anticipated that the created wetlands will resemble the reference wetlands more closely in regard to species frequency, as well as species richness and cover.

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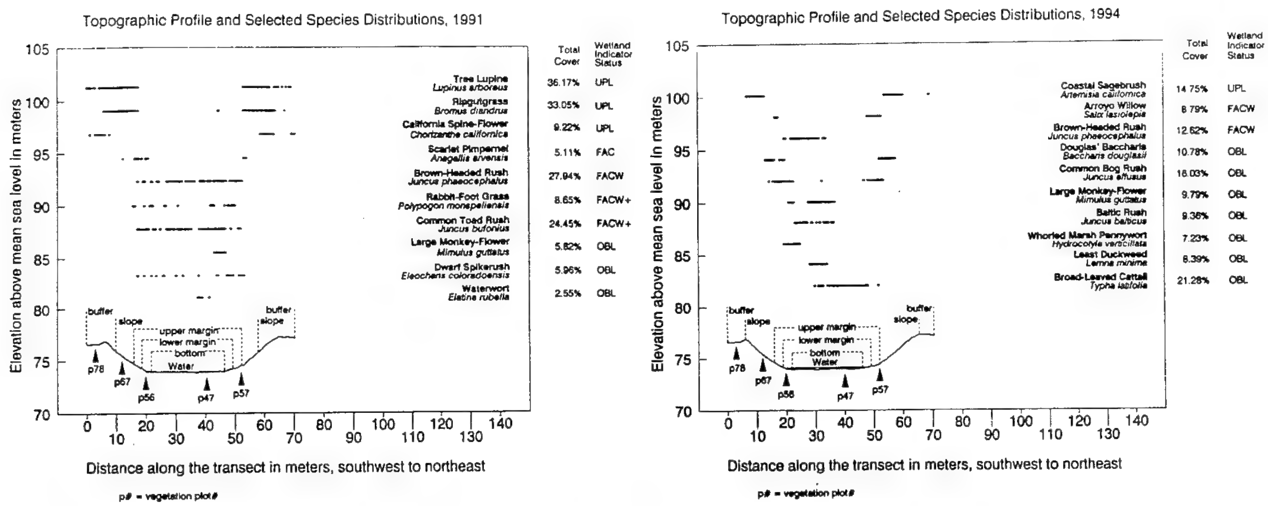

Figure 1. Transect Profiles, Created Wetland Live Oak Springs, 1991, 1994.

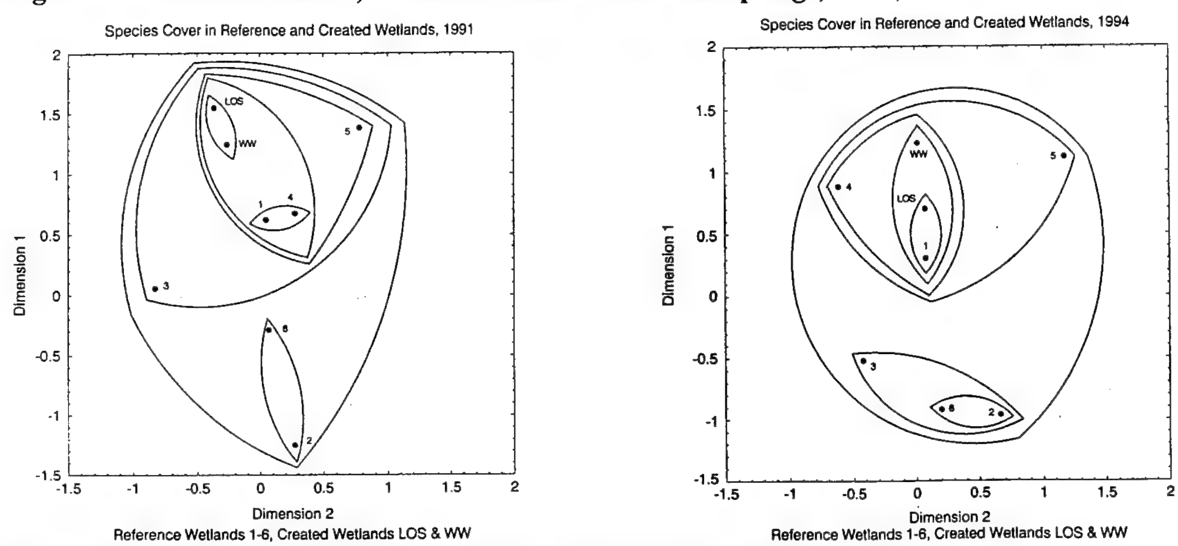

Figure 2a. Clustering Embedded in MDS Configurations, Species Cover, 1991, 1994.

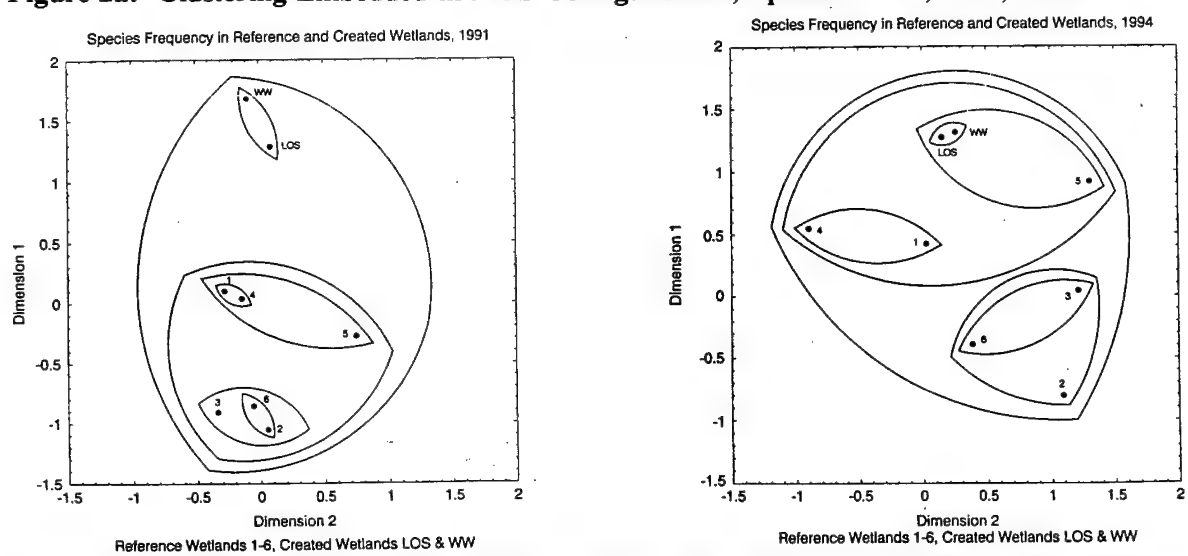

Figure 2b. Clustering Embedded in MDS Configurations, Species Frequency, 1991, 1994.

SESSION CP3

CRITICAL PROCESSES: WETLAND VEGETATION II

Jack E. Davis, PE, Chair

AN ORDINATION OF MARSH COMMUNITY TYPES AND ASSOCIATIONS AT JEAN LAFITTE NATIONAL PARK IN SOUTHEAST LOUISIANA

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Abstract

A detailed wetland vegetation study was conducted in the Barataria Unit of Jean Lafitte National Historical Park, Louisiana to determine the predominant species types and associations in this diverse marsh system. Ordination was used to establish whether there were any patterns in species groupings that corresponded with environmental factors and gradients across the study area. Transects on the western portion of the study area closest to Lake Salvador were generally characterized by plant species which can tolerate moderate levels of salinity, while less tolerant, freshwater species dominated the marshes to the east. A total of 66 plant species were sampled on all habitat types. Resurveys of permanent sampling sites established 10 years ago showed little change in species composition in contrast to predicted trends. Spatial analysis showed that marsh hydrology and flotant condition may contribute to species types and distribution.

HYDROLOGIC EFFECTS ON SPECIES COMPOSITION AND PRODUCTIVITY: A MESOCOSM APPROACH

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Hydrology can significantly affect plant species composition and productivity in wetlands (Haag, 1983, Nicholson and Keddy, 1983). Our study site, L-Lake, was created in 1985 to serve as a cooling reservoir for a nuclear production reactor on the Savannah River Site in Aiken County, South Carolina. In 1987, we planted

5,700 m of the shoreline with wetland species representative of a regional lake system as a good faith effort toward a Balanced Biological System. Since L-Reactor shutdown, L-Lake has been maintained at a constant water level. Recent management proposals for L-Lake have included: (1) maintaining a constant water level, (2) fluctuating the water level, and (3) permanent drawdown.

We examined the effect of hydroperiod on vegetation and soil chemistry in a mesocosm experiment by subjecting substrate cores (33 X 28 X 14 cm tub) from the shoreline of L-Lake to the three proposed water regimes: flooded (surface flooded), variable, and shallow (-15 cm). The objectives of this study were to determine how hydroperiod influences plant species composition, plant productivity, and soil chemistry. In addition we wanted to determine if the mesocosm technique was suitable for studying wetland systems.

We measured species percent cover at the beginning and end of the experiment. At the end of the growing season, we measured shoot heights for five randomly chosen individuals of *Panicum hemitomon* and *Eleocharis quadrangulata* for each tub. At the end of the growing season plants were harvested for above and below ground biomass. Sediment samples collected at the beginning and end of the experiment were analyzed for percent solids, percent organic matter, cation exchange capacity, pH, and percent sand, silt, and clay. Soil redox, water chemistry measurements of temperature, pH, dissolved oxygen, and conductivity were recorded weekly for each tank.

Species percent cover data indicated no major shifts in dominance among the treatments. The number of plant species that emerged from sediment cores from L-Lake did not differ among three experimental water regimes. Community composition changed over time and differed among treatments. Principal Components Analysis indicated that the shallow and variable treatments both diverged from the flooded treatment. Jaccard's Community Similarity Index indicated that plant composition in October was only 17-23% similar to the initial community; similarity was lowest in the variable treatment. Above ground biomass did not differ among the treatments while below ground biomass of the flooded and variable treatments increased relative to the shallow hydroperiod. However, analysis of individual species above ground biomass indicated that productivity is species-dependent (Table 1). Measured soil parameters showed no significant differences except for an increase in organic matter in the flooded and variable treatments. Soil redox readings reflected the hydroperiod changes. We observed only minor fluctuations in water chemistry readings as could be expected in natural systems.

This study indicates that changing the water level management regime in L-Lake from constant to fluctuating would not change species diversity by adding new species, but would alter

Table 1. ANOVA of above ground biomass (g/tub) for species among hydrologic regimes. Means with the same letter are not significantly different across treatments (P>0.05).

SPECIES	FLOODED MEANS		VARIABLE MEANS		SHALLOW MEANS	
Alternanthera philoxeroides	77.55		67.64		23.49	
Andropogon spp.	2.94	A	3.87	A	34.61	B
Aneilema keisak	6.19	A	31.14	B	30.62	B
Bacopa caroliniana	15.35		12.73		3.33	
Cyperus strigosus	7.25		6.78		2.89	
Eleocharis quadrangulata	85.26		56.68		58.26	
Habenaria repens	0.64	A	1.34	AB	3.28	B
Hydrocotyle umbellata	6.09	A	4.07	AB	1.55	B
Juncus effusus	1.89		1.07		1.11	
Sacciolepsis striata	1.79		12.66		8.43	

composition of the existing community, at least over the short-term. This mesocosm technique seemed to be appropriate for this type of study.

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VEGETATIVE STUDY OF SELECTED WETLAND SITES IN THE LOWER COLUMBIA RIVER

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Abstract

A vegetative study was performed at five wetland sites in the Lower Columbia River in June 1993. Two of the sites are constructed wetlands (islands constructed with dredged material) and have been studied previously. Therefore, the objective was to add to the existing database of the biological characteristics of the sites, and to continue monitoring of constructed wetlands. The other three sites had not been studied previously and the objective was to develop a baseline of information in anticipation of potential man-made improvements to the wetlands. Data collection included information on vegetative characteristics, topographic information, and benthic sampling.

Results suggest that while elevation within a site may be a major factor which affects vegetative communities, elevation alone may not be a good indicator of vegetative communities. Other factors such as salinity, soil type (grain size), and flow characteristics may affect plant communities in the Lower Columbia River.

SWAMP FOREST VEGETATION AND HYDROLOGY ALONG MICROTOPOGRAPHIC GRADIENTS

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Factors that influence the composition of plant communities in southeastern coastal plain swamps are complex and difficult to quantify. Phenotypic variation, microtopographic gradients in surface and subsurface drainage, soil chemical and microbial reactions to dissolved oxygen fluctuations, stochastic flooding events and regeneration processes, and disturbance combine to shape floodplain plant community structure.

We analyzed the vegetation of two swamp forests along Durham Creek in Beaufort County, N.C., in relation to long term surface water flooding regimes, elevation, soils, and other environmental factors. For convenience, they are called the upstream stand and the downstream stand. Regression relationships between the two sites and a nearby gaging station were used to hindcast 25 years of surface flooding regimes. Over three thousand individual plant microsite elevations were surveyed and correlated with continuous stage recorders and gage data to examine individual species responses to varying flooding regimes. Soil physical and chemical characteristics were described in detail and a comprehensive view of the plant community-environmental complex was developed with direct gradient analyses and two multivariate ordination techniques (Bledsoe 1993).

Distributions of species within elevational increments reflect a variety of responses to differing hydrologic and edaphic gradients and demonstrate that communities intergrade continuously along the environmental complex associated with elevation (Tables 1-2). An elevational difference of 10 cm (3.9") can represent up to a 20% difference in growing season surface flooding frequency.

These results have implications for the restoration of forested wetlands. Plant species response to flooding is affected by the combined action of many forces including microsite hydrology and nutrient availability. For example, the occurrence of _Fraxinus pennsylvanica_ in the downstream stand appears to be linked to an affinity for calcium, a high Ca/Mg ratio, and a specific moisture regime associated with a narrow range of elevations. Unpredictable climatic conditions following planting, restoration site soils which differ drastically from those of reference ecosystems, and plant material of unknown origin complicate restoration. These factors, combined with marked differences in flooding frequency occurring over a few centimeters, make precise design for achieving a specific community structure formidable at best.

Table 1. Direct gradient analysis of downstream stand on Durham Creek near Edward, NC. Relative density and relative basal area of tree and shrub species > 1 m height within elevational increments. Increments of 0.15 m (0.5 ft), 0.30 m (1.0 ft), and 0.45 m (1.5 ft) above listed datum. Zero indicates present in numbers < 0.49. Relative density listed on the left and relative basal area on the right. Mean elevation data are ± one SD. *For the understory stratum, relative frequency and relative cover summaries of individuals < 1 m height provided within elevational increments.

				Elevational Increment								
		Mean	(ft)	8.07	8.57	9.07	9.57	10.07	11.07	12.07	13.57	15.07
Species	N	Elevation	(m)	2.46	2.61	2.76	2.92	3.07	3.37	3.68	4.14	4.59
Taxodium distichum	45	2.72 ± 0.12		24 77	12 42		3 16					
*Saururus cernuus**	34	2.72 ± 0.09		4 0	4 3	3 1						
Fraxinus caroliniana	121	2.74 ± 0.09		44 5	32 5	16 2	4 1					
*Itea virginica**	22	2.74 ± 0.11		7 0	2 1	1 3	1 0					
*Boehmeria cylindrica**	14	2.78 ± 0.22		4 0	1 0	1 0			1 0			
Nyssa aquatica	36	2.83 ± 0.17		9 18	7 11	5 7	5 10	2 7	1 3			
*Decumaria barbara**	50	2.86 ± 0.24			0 0	3 2	9 17	12 2	1 0			
*Campsis radicans**	23	2.87 ± 0.12			1 0	2 0	4 6	1 0				
*Osmundia regalis var. spectabilis**	26	2.89 ± 0.25			1 1	3 4	1 3		1 1	1 1		
Fraxinus pennsylvanica	20	2.89 ± 0.18			3 9	3 17	3 21	3 28				
Leucothoe racemosa	22	2.92 ± 0.30			6 0	2 0		2 0	1 0	1 0		
*Woodwardia areolata**	232	2.96 ± 0.39		20 92	17 71	13 25	14 51	19 58	17 43	10 11	1 0	3 0
Acer rubrum	305	3.04 ± 0.44		18 1	30 17	43 18	45 22	37 23	19 12	23 26	8 4	9 0
Liquidambar styraciflua	70	3.16 ± 0.62			4 7	9 8	11 10	11 21	9 18	5 18	3 3	4 0
*Parthenocissus quinquefolia**	41	3.16 ± 0.58			0 1	4 1	3 0	2 0	4 1	2 0	1 0	3 0
Cyrilla racemiflora	20	3.22 ± 0.41			1 0	2 0	3 0	2 0	7 0	4 0		
Nyssa sylvatica var. biflora	49	3.24 ± 0.53			3 10	6 26	5 20	4 18	17 67	1 12	7 0	2 0
Clethra alnifolia	37	3.43 ± 0.50		3 0	1 0	3 0		2 0	12 0	16 0	2 0	
*Leucothoe racemosa**	6	3.49 ± 0.71			0 0	0 0		1 0	1 1	1 0	1 0	
*Osmundia cinnamomea**	9	3.51 ± 0.69			0 0			2 3		1 4	2 0	
Ilex opaca	78	3.53 ± 0.77			1 0	3 0	10 0	30 3	12 0		15 2	13 2
Magnolia virginiana	11	3.64 ± 0.62			1 0			2 0		5 1	5 0	
Persea borbonia	31	3.69 ± 0.43				0 0	4 0	2 0	10 0	13 0	10 2	
*Mitchella repens**	74	3.84 ± 0.82			1 0	1 0	5 0	4 3	14 8	13 10	15 2	14 2
Quercus michauxii	7	4.14 ± 0.65							3 0	2 2		6 27
*Leucothoe axillaris**	27	4.26 ± 0.43							1 5	7 44	16 74	3 10
*Symplocos tinctoria**	14	4.50 ± 0.84							1 0	4 2	4 3	6 7
% Growing Season Surface Flooding Frequency				**56.01**	**27.16**	**8.26**	**1.46**	**0.09**	**0**	**0**	**0**	**0**
% Annual Surface Flooding Frequency				61.31	28.79	6.52	0.98	0.05	0	0	0	0

Table 2. Direct gradient analysis of upstream stand on Durham Creek near Edward, NC. Relative density and relative basal area of tree and shrub species > 1 m height within elevational increments. Increments of 0.15 m (0.5 ft) and 0.30 m (1.0 ft) above listed datum. Zero indicates present in numbers< 0.49. Relative density is listed on the left and relative basal area on the right. Mean elevation data are ± one SD.

				Elevational Increment								
		Mean	(ft)	13.5	14	14.5	15	15.5	16.5	17.5	18.5	19.5
Species	N	Elevation	(m)	4.11	4.27	4.42	4.57	4.72	5.03	5.33	5.64	5.94
Fraxinus caroliniana	19	4.27 ± 0.04		8 0	2 0							
Taxodium distichum	6	4.45 ± 0.15			1 8	1 3	0 5					
Leucothoe racemosa	45	4.45 ± 0.36		8 0	5 0	5 0				3 0		
Clethra alnifolia	138	4.52 ± 0.34		14 0	15 0	6 0	13 0	7 0	2 0	6 0	2 0	
Cyrilla racemiflora	35	4.52 ± 0.35		5 0	4 0	3 0	1 0		3 0	2 0		
Quercus laurifolia	34	4.57 ± 0.58		5 3	4 1	3 5	0 0		1 1	1 11	3 0	1 0
Nyssa sylvatica var. biflora	126	4.67 ± 0.60		9 55	11 58	12 39	5 26	8 19	8 19	3 6	3 3	6 10
Leucothoe axillaris	37	4.68 ± 0.38				12 0		2 0		5 0		
Liquidambar styraciflua	192	4.69 ± 0.65		23 29	19 21	11 16	7 30	15 35		5 17	9 20	12 8
Magnolia virginiana	29	4.75 ± 0.51		1 1	2 0	0 0	2 3	4 2	4 1			1 0
Persea borbonia	89	4.79 ± 0.64		2 0	7 0	9 0	5 0	4 1	4 0	9 0	3 0	4 0
Lyonia lucida	19	4.82 ± 0.56			2 0	2 0			2 0	3 0	2 0	
Acer rubrum	187	4.84 ± 0.81		19 10	12 9	13 31	18 23	6 4	6 2	3 4	5 2	24 13
Ilex opaca	330	4.89 ± 0.53		3 0	10 2		40 8	29 9	31 8	30 15	27 10	9 2
Fagus grandifolia	11	5.10 ± 0.43					1 0	1 0	2 8	2 0	2 0	
Quercus michauxii	44	5.29 ± 0.57				1 3	3 3	3 1	7 14	7 14	14 30	3 0
Gordonia lasianthus	2	5.37 ± 0.50						1 0			2 1	
Symplocos tinctoria	41	5.38 ± 0.62					1 0	9 0	5 0	9 0	9 0	4 0
Quercus nigra	19	5.64 ± 0.74						4 17	2 11	3 4	5 0	4 0
Ilex coriacea	8	5.84 ± 0.86							3 0	1 0		3 0
Liriodendron tulipifera	34	6.04 ± 0.86					1 1	4 13	2 5	1 8	11 32	16 55
Pinus taeda	4	6.20 ± 0.98							1 7	1 11		2 11
% Growing Season Surface Flooding Frequency				**47.64**	**18.68**	**4.83**	**0.57**	**0.03**	**0**	**0**	**0**	**0**
% Annual Surface Flooding Frequency				60.79	29.75	6.72	0.7	0.02	0	0	0	0

Sites with similar flooding regimes and soils often have different successional trajectories. These stands are on the same stream with almost identical annual flooding frequencies, soils, and ages, yet they are rather different. Which would be the better reference ecosystem? Perhaps it would be better to establish a range of successional trajectories for such systems in the region. Every practical effort should be made to select the correct species composition for a particular site while acknowledging that we may still miss the target. Elegant plans combine careful application of a generalized reference ecosystem design with flexible success criteria and contingency plans which allow for unforeseen but acceptable successional directions.

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SESSION SM3

STEWARDSHIP AND MANAGEMENT: CHANGE ASSESSMENT AND CUMULATIVE IMPACT ANALYSIS

Mark R. Graves and Larry Waggoner, Co-Chairs

MONITORING CHANGES TO BOTTOMLAND HARDWOOD FORESTED WETLANDS

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Introduction

This goal of this study, conducted under the Corps of Engineers Wetlands Research Program, was to quantify changes in forest cover in the Cache River, Arkansas (Figure 1) watershed during the period for which reliable recorded data are available (1935 present).

Source Materials and Methods

Loss of forest cover in the basin between 1935 and 1975 was calculated for the entire watershed using data from quadrangle maps produced by the US Army Corps of Engineers (USCE) and the US Geological Survey (USGS). More detailed analysis of forest cover and forested wetlands was conducted in the lower watershed area (approximately 125,000 ha) highlighted in Figure 1.

The basic methodology used in this study was a time series analysis of available data related to the forest cover, wetlands, and soils in the Cache River watershed. These analyses were conducted used a combinated of GIS and image processing techniques. The four data sources utilized included historical topographic maps, National Wetland Inventory (NWI) maps, USDA county soil surveys, and Landsat satellite imagery.

Analysis and Discussion

Forest cover in the entire basin decreased from 168,000 ha in 1935 to approximately 60,000 ha in 1975. Forest cover change between the two dates was characterized by comparing the two dates of forest cover data using a GIS. Table 1 presents the results of this analysis.

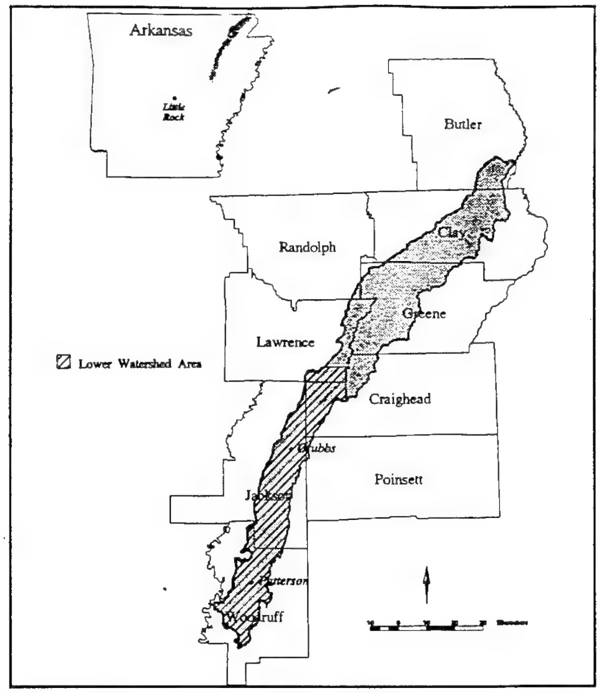

Figure 1. Study Area.

Table 1 Change in Forest Cover 1935 to 1975 (hectares)	
No Change - Forest	49,307
Change from Forest to Nonforest	118,590
No Change - Nonforest	109,883
Change from Nonforest to Forest	10,240
Total	288,020

Table 2
Comparison of Forest Cover and Forested Wetlands in Lower Watershed Area (hectares)

Date	Forested Area	Forest Area with Hydric Soils	Forest Area with Hydric Soils (%)
1935	70196	58736	84
1975	24288	21850	90
1987	24482	21569	88

Assessment of Forested Wetlands

To estimate how much of the forest cover represented forested wetlands in the lower watershed area, the forested areas derived for the various sources were compared with hydric soils data (USDA 1991). The results of this analysis are presented in Table 2.

Since the Cache River watershed was almost completely forested in its pristine state (USFWS 1984), the comparison of forest cover and hydric soils indicates that 84% of the 1935 forest cover in the lower watershed area were once forested wetlands. As the hydrologic characteristics of the basin have changed since 1935, the 1975 estimated of forested wetland area will tend to be high, as all forested areas with hydric soils may no longer experience the inundation period required to meet the legal definition of a forested wetland.

Recent forest cover changes in the lower watershed area were characterized using Landsat satellite data for five dates (1972, 1974, 1976, 1980, and 1987). Little change was noted in forest cover area during this period, although the results from the 1987 TM image (the only TM image analyzed) reflected 1300 more ha of forested cover than the 1980 MSS data. The increase noted in the 1987 data are more than likely a result of the increased spatial resolution (30 meters) of the Thematic Mapper (TM) sensor. The TM sensor was able to detect small, isolated forest stands which were indistinguishable in the older MSS data (80 meter resolution).

Summary

The Cache River watershed has experienced the loss of approximately 118,000 ha of bottomland hardwood forests since 1935. Most of this loss occurred between 1935 and the early 1970's, with forest cover remaining essentially unchanged in the lower watershed since the early 1970's. In the lower watershed area 48,627 ha of forest cover has been removed. Of this, based on a comparison with hydric soils data, 37,167 ha were once forested wetlands.

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A SPATIAL SAMPLING NETWORK FOR MONITORING AND MANAGING MARSH HYDROLOGY IN COASTAL LOUISIANA

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An interagency research project is underway at Jean Lafitte National Historical Park and Preserve (JLNHPP) to map and to monitor the vegetation, soils, and hydrology of the Barataria Unit marsh in coastal Louisiana. The preserve covers 8400 ha of emergent marsh, cypress swamp, and bottomland hardwood typical of the Mississippi River delta. A grid network of sampling stations was established to augment the development of a natural resource data base and predictive model for evaluating ecosystem management alternatives for the park.

Spatial resolution of the sampling grid was 250 m in the east-west direction and 500 m in the north-south direction to conform with site geomorphology. Each grid point location was censused during 1994-1995 to characterize marsh type and substrate, interstitial porewater salinities, water level, and mat movement.

Major differences were found in the quality and distribution of floating and rooted marshes about the park, marsh hydrology, and salinity distributions. Data from this study are being incorporated into a GIS data base and ecosystem model for the park. The resultant field research and computer model will afford managers with a functional framework on which to base management decisions and to monitor management success.

MONITORING CHANGES IN PLANT COMMUNITIES WITHIN WATER CONSERVATION AREA 3A OF THE EVERGLADES

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Distribution and percent cover of plant species were examined in relation to hydroperiod (i.e., depth and duration of flooding) along eight transects in Water Conservation Area (WCA) 3A of the Everglades, Florida. Transects were monitored between 1978 and 1984 to detect changes in plant communities resulting from the

operation of a water control structure (S-339) which improved distribution of water to overdrained portions of northern WCA 3A. These data supplied the baseline for conventional photogrammatic techniques which were used to interpret infrared aerial photography. Data was transferred to an ARC INFO GIS data base by ARCSCAN. Computer generated GIS maps provided a mechanism to monitor spatial and temporal changes in plant communities, and was particularly useful in documenting the spread of *Typha* spp.

MONITORING WETLAND RESTORATION BY INTEGRATING GIS AND IMAGE PROCESSING TECHNOLOGY WITH CONTINUOUS DATA COLLECTION

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The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) was created to address the critical problem of wetland loss in Louisiana through constructing and managing coastal vegetated wetland enhancement projects. The Coastal Restoration Division of the Louisiana Department of Natural Resources and the Southern Science Center of the National Biological Service monitor 57 projects under CWPPRA. Monitoring must provide a scientific evaluation of the effectiveness of each coastal wetland restoration project in creating, restoring, protecting, and enhancing coastal wetlands in Louisiana and achieving long-term solutions to arresting coastal wetland loss in Louisiana. In order for the above mandates to be achieved, a monitoring approach was developed that incorporated a level of spatial and temporal sampling sufficient to address project- specific goals and objectives.

The Coastal Restoration Division is installing and maintaining a network of data collection platforms (DCP) for various physical and biological variables along the coast (figure 1). Site-specific DCP measurements include variables such as water level, water velocity, salinity, conductivity, temperature, windspeed, and wind direction. Data are recorded hourly and transmitted to a centralized database via the Geostationary Operational Environmental Satellite network or manually through electronic downloading to a laptop computer. These data provide detailed critical monitoring information that can be statistically modeled and integrated with geographic information system (GIS)

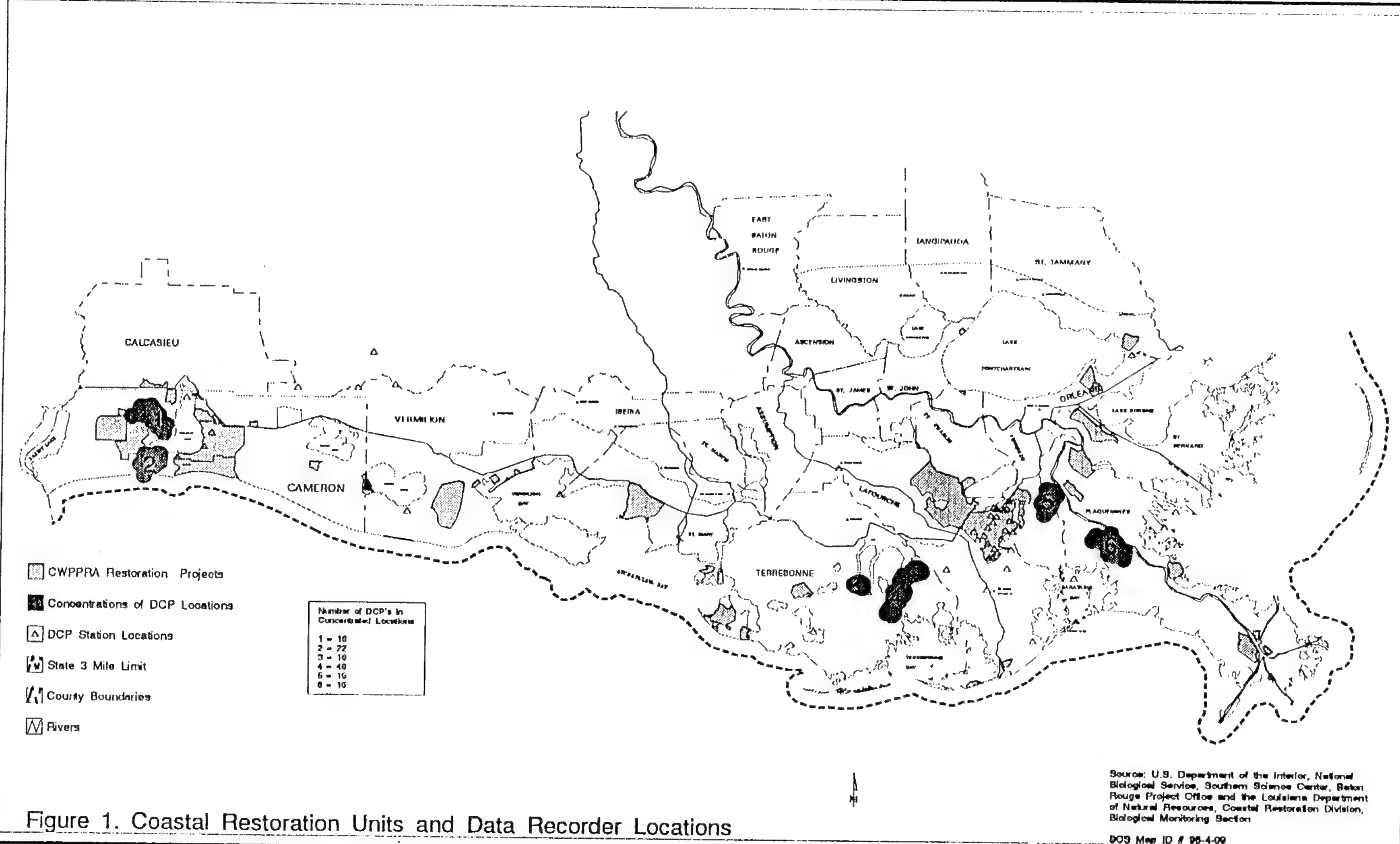

Figure 1. Coastal Restoration Units and Data Recorder Locations

analysis in order to provide information about larger scale processes.

The Southern Science Center is conducting GIS analysis and image processing support for monitoring of habitat conditions. High resolution (1:12,000, 1:18,000, 1:24,000) color infrared photography of project areas will be obtained several times over the monitoring period. The photography will be georeferenced using ground control points and then photointerpreted using a classification scheme modified after Cowardin et al. (1979). The photography and the landcover maps will be converted to digital format. Multidate wetland trend maps and statistics, indicating loss and gain of wetlands over time, can be created for each project by comparing landcover data sets before and after implementation.

The combination of these two datasets provide a large scale perspective critical to the efficient planning and evaluation of the CWPPRA long-term coastal monitoring program. To combine these datasets the DCP platform locations and habitat mapping ground control points are georeferenced using global positioning surveying (GPS) and stored in a central database which links the temporal biological data with the digital spatial data. In this manner long term biological records are maintained in conjunction with their spatial connectivity relationships. A GIS is used to query and display the site-specific biological and larger scale habitat data identifying their spatial relationships. In this manner we are able to discern specific structural and functional changes from the ground sampling and also integrate it with the large scale habitat data. This gives us the ability to extrapolate project specific effects to a hydrologic basin and eventually coastwide level.

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ANALYSIS OF PLANT SUCCESSION IN LOUISIANA'S DELTA USING REMOTE SENSING

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The Atchafalaya River Delta in Louisiana is ecologically, geologically, and economically very important, but not well understood. The mechanisms of sediment transport, the accumulation of sediment, and the integral role of plants in the consolidation

of sediment into identifiable land are of particular importance in the understanding of the deltaic process. I will present data on plant succession on recently accreted land in the Louisiana Chenier Plain. These remotely sensed data on plant succession were collected utilizing National Aeronautics and Space Administration's (NASA) Calibrated Airborne Multispectral Scanner (CAMS). The CAMS data analysis indicate that accretion is occurring along the Chenier Plain. Further, the CAMs data indicate that a successional series of plant species is playing a significant role in the consultation of the sediment.

SESSION WT1

WETLAND EDUCATION AND TRAINING

John W. Bellinger, Chair

WETLANDS: FERTILE AREAS FOR EDUCATION

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We have designed and carried out research and field activities in natural, restored, and managed Southeastern wetlands with teachers and students ranging from K-16. The teachers and students have learned both high-tech and low-tech science methods and skills that have applications and connections to many academic disciplines. For example, we have made connections of wetlands to Geology and Geography by studying locations of wetlands with emphasis on natural landscape features that relate to wetlands hydrology, restoration, development, preservation, conservation, and management. We connected Mathematics to wetlands by mathematical and statistical treatment of data on wetland plants, vertebrates, and water. Sociological connections to wetlands are made by pointing out that many rural and urban cultures developed with wetland at their center. Connections to Economics are made by virtue of the fact that local, regional, and national laws and regulations impact the economic development of an area. We connected Biology to wetlands in that students study the biotic and abiotic components of wetlands and the ecological principles functioning in a wetlands Chemistry and Physics are connected by emphasizing that the chemical and physical features of water affect water quality (i.e. degree of pollution). Language Arts, English, History, Political Science are connected to wetlands through written and oral assignments, and study of historically important early human settlements, development of transportation and commerce, and the study of government control and regulation of wetlands.

At the college level, our students have used both natural and restored wetlands to study hydrology, vegetation, mammals, birds, reptiles, and amphibians. They have increased their problem

solving skills by making careful measurements over time and precisely recording data, presenting data, and making predictions based on collected data. They have demonstrated analytical skills by identifying controls, experimental units and variables in a field experiment, discovered how results relate to their hypothesis, and described examples of ecological principles observed in the field. Effective group skills are learned by students working cooperatively to achieve a common goal/objective. Through oral and written reports communication skills have been enhanced and instructors are able to discern what a student knows and how a student reasons.

Our high school students have increased their knowledge of wetlands and environmental science through hands on experiences in restored and natural wetlands. Students have used statistical methods to organize data and produce formal presentations making inferences and drawing conclusions from their own research. At the middle school level, students have been able to identify wetland biotic and abiotic characteristics, develop classification skills, develop and use tables and graphs to describe, analyze, and evaluate data. At the elementary school level, students have been able to make field observation, measurements, collect samples, and learn to organize data.

In conclusion, by utilizing wetlands in K-16 science curricula we have accomplished two objectives. One is to educate students and teachers about wetlands and the other is to use wetlands as a vehicle to apply and connect their science knowledge and skills to a number of academic disciplines. Our success in working with teachers and students suggests that other state and federal agencies working on cleanup, restoration, monitoring, or mitigation of wetlands could benefit and add value by including an education component in the criteria for restoring or managing a wetland.

WETLANDS TRAINING IN THE CORPS OF ENGINEERS

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Wetlands are a major focus for many U.S. Army Corps of Engineers (Corps) Civil Works Program. Because wetlands are of such importance, research was needed on wetlands functions and processes. The Wetlands Research Program, and the earlier Dredged Material Research Program, conducted by the Corps Waterways Experiment Station at Vicksburg, Mississippi, were carried out to

provide Corps field personnel with the needed wetlands information.

While research reports are useful, an effective way to transfer such technology to field personnel is through formal training. During training, research results can be presented and feedback between instructors and students can facilitate the transfer of research technology to those who need it the most.

The Corps formal training program is called "Proponent Sponsored Engineer Corps Training" (PROSPECT) and is managed by the U.S. Army Engineer Division, Huntsville (Alabama), Training Center (for information, telephone 205-722-5807). PROSPECT courses are taught by Corps staff or contracted out to universities or private sector contractors.

The Corps wetlands training program includes six wetland courses currently being taught at a number of sites around the country. Two new wetland courses are being planned for fiscal year 1996. These courses collectively have a total of 26 weeklong sessions. Following are brief descriptions of the wetland courses in the Corps PROSPECT program. Most of these courses are open to personnel from other agencies, on a space available basis; Corps staff get first priority.

<u>Wetlands Overview for Executives</u>. This is a two-day course intended for executive level personnel, such as district or division engineers and their deputies, and division or branch chiefs at headquarters, divisions, and districts. The course provides a broad overview of wetlands, including wetlands identification, classification, delineation, and evaluation of functions and values. Wetlands restoration is addressed.

<u>Fundamentals of Wetlands</u>. This is a week long course intended for Corps planners and natural resources managers who have no, or very limited, knowledge or experience with wetlands. Students are provided with state-of-the-art basic knowledge of wetland flora and fauna, hydrology, soils, and ecology. The course emphasizes wetlands functions and values in an ecosystem perspective. Both saltwater and freshwater wetlands are addressed.

<u>Wetlands Evaluation Procedures</u>. This week-long course provides an introduction and overview of wetlands evaluation procedures and techniques currently in use and being developed (e.g., WET, HGM). An in-depth discussion and field exercise covering selected techniques form the basis of the course.

<u>Wetlands Development and Restoration</u>. This week-long course provides introductory training in the concepts and practices of wetlands restoration and development in both salt and fresh water systems. The course provides hands-on experience in actually planting marshgrasses and bottomland hardwoods.

Interagency Wetlands Identification and Delineation. This week-long interagency course teaches wetlands delineation based on the current Federal Wetland Delineation Manual (1987). It provides the student with a basic understanding of the interaction of soils, vegetation, and hydrology. Upon completion, successful graduates will possess the background necessary to identify wetlands and determine their legal boundaries.

Wetland Functions and Values. This week-long course is designed for the experienced regulatory employee. It provides a review of wetland functions and their values and presents current wetland evaluation techniques tailored to the needs of the regulatory program.

Wetland Hydric Soils. This week-long course is proposed for fiscal year 1996. It will provide an overview of wetland hydric soils and the relationship of these soils to wetlands classification, restoration, and hydrology.

Constructed Wetlands. This week-long course is also proposed for fiscal year 1996. This advanced level course will provide technical knowledge on how to construct wetlands from a planning, engineering, design, construction, and operations viewpoint. Monitoring requirements will be addressed.

SESSION RE7

RESTORATION, PROTECTION, AND CREATION: LOWER MISSISSIPPI RIVER FLOODPLAIN FOREST RESTORATION

Dr. Hans M. Williams, Chair

COMPARISONS OF PLANT COMMUNITY ATTRIBUTES AMONG RESTORED AND MATURE BOTTOMLAND HARDWOOD FORESTS OF SOUTHWESTERN KENTUCKY

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Introduction

The agricultural productivity of bottomland soils led to extensive forest clearing in the last century. There is now considerable interest in restoring these forests. Without adequate advance regeneration, heavy-seeded species (e.g., oaks) may not reclaim their historical prominence. Ecological restoration aims to restore structural and functional attributes of damaged ecosystems to pre-disturbance conditions. It is a relatively recent endeavor, with few opportunities to study long- term development.

During the 1940's, 400 ha of bottomlands in agriculture near Kentucky Lake in the Tennessee Valley were reforested (planted type forest). Adjacent fields regenerated naturally (natural type). A few stands (100+ years old) were never converted to agriculture, and are the best representations of the original bottomland forest (mature type). This unique arrangement of restored and mature stand types on similar soils in similar watersheds allows for comparison of plant community attributes. Our objective was evaluate the development of mature characteristics in restored stands.

Methodology

Three forests of each type along three Tennessee River tributaries were analyzed. Each watershed contains one stand planted in 1942 with baldcypress and Atlantic white-cedar (<u>Chamaecyparis thyoides</u>), and an adjacent naturally regenerated stand. One stand was replanted in 1945 with black gum, green ash, red maple, eastern cottonwood, loblolly pine (<u>Pinus taeda</u>), and sycamore. We inventoried the total plant communities in 1993. Because of record flooding along the Mississippi River, Kentucky

Table 1. Mean overstory and midstory species importance values (IV) by stand, where: IV = (relative frequency + relative density + relative basal area) / 3. Asterisks indicate heavy-seeded species found in the overstory.

Species		Overstory IV			Midstory IV		
		Mature	Natural	Planted	Mature	Natural	Planted
Acer rubrum	red maple	19.1	24.3	31.1	27.6	20.8	40.0
Liquidambar styraciflua	sweetgum	17.6	35.0	14.3	15.0	6.9	1.5
Ulmus americana	American elm	13.1	13.6	5.5	30.4	44.6	36.7
Quercus palustris *	pin oak	6.8					
Fraxinus pennsylvanica	green ash	6.8	7.7	4.9	1.9	8.2	5.9
Celtis laevigata *	sugarberry	6.0	2.3		13.4		5.5
Carpinus caroliniana	ironwood	4.1	0.7	0.6	2.3	7.3	
Liriodendron tulipifera	tulip-poplar	3.7	2.2	2.5		3.3	
Quercus lyrata *	overcup oak	3.5					
Carya ovata *	shagbark hickory	3.5					
Quercus michauxii *	swamp chestnut oak	3.2			3.7	1.2	
Betula nigra	river birch	2.7	2.0	2.3		1.4	
Platanus occidentalis	sycamore	1.8	5.8	14.2			
Quercus falcata var. *pagodifolia* *	cherrybark oak	1.8					
Acer negundo	box-elder	1.6	5.3	1.4	2.4	3.0	1.5
Carya cordiformis *	bitternut hickory	1.5			3.3	1.3	
Nyssa sylvatica *	black gum	1.3					
Diospyros virginiana *	persimmon	1.1					
Prunus serotina *	black cherry	0.8					
Gleditsia triacanthos *	honey-locust		0.7				
Ulmus alata	winged elm		0.4	0.6			
Quercus rubra	red oak					1.3	1.7
Populus deltoides	eastern cottonwood			1.0		0.9	
Taxodium distichum	baldcypress			21.7			7.2
Total number of species		19	12	12	9	12	8

Table 2. P values for the observed multi-response permutation procedures statistics for planned comparisons of plant community composition and abundance, with stand types as the groups. The second values for understory are for analyses excluding poisin ivy (*Toxicodendron radicans*). P values represent the probabilities that the groups compared were not different.

Groups compared	Overstory	Midstory	Understory	
restored and mature	0.0058	0.5148	<0.0001	0.0780
natural and planted	0.0731	0.3898	0.0676	0.1915
natural and mature	0.5223	0.4895	0.0002	0.2706
planted and mature	0.0271	0.5115	0.0030	0.0271

Lake was maintained at an extremely high level. This flooded one creek, making understory inventory there impossible. We compared overstory, midstory, and understory species compositions using multi-response permutation procedures. We analyzed the variances in density and basal area to evaluate overstory structural differences.

Results and Discussion

The number of overstory species was greater in the mature type (19) than in the restored types (12). Oaks and hickories accounted for most of the overstory composition differences between restored and mature stands. Pin oak had the highest relative basal area (29%, importance value = 14%) in one mature stand, and overcup oak was had a high overstory importance value (11%) oak in another mature stand. Sweetgum and red maple accounted for >50% of the overstory basal area in all but one of the restored stands. Natural regeneration will replace light- seeded species, but heavy-seeded species must be replanted. Mean tree height and diameter were larger and stem density was lower in the mature type than in the restored types. Mean basal areas were not significantly different among stand types.

The current structural characteristics of both the restored and mature stand types are comparable to those of similar forests of the same age (e.g., Muzika et al.). There were no differences among the stand type midstories (Table 2). The midstories included 14 canopy species, 12 of which were in the understories. Poison ivy was the most abundant understory species, with greater abundance in the mature type. Ignoring poison ivy, we believe that the understory was adequately restored after fifty years. This is contrary to the prevailing opinion that understories take much longer, perhaps centuries, to recover from disturbances less severe than agriculture.

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ESTABLISHMENT OF MIXED-SPECIES PLANTATIONS OF BOTTOMLAND HARDWOODS

ESTABLISHMENT OF MIXED-SPECIES PLANTATIONS OF BOTTOMLAND HARDWOODS

J.C.G. Goelz

The objectives for establishing mixed-species plantations are assumed to include: (1) produce a forest more diverse in composition and more natural in appearance than monocultures; (2) provide a more diverse community of associated flora and fauna; (3) provide timber production close to that of monocultures.

Types of Mixed-Species Plantations

Intercropping mixtures involve two or more species of greatly different initial growth rates or products. Mixed monotypes involves planting patches of species adjacent to each other. True mixtures are intimate mixtures of species where the arrangement of species is by alternate rows, haphazard, or by some fixed planting scheme.

Intercropping Mixtures

A species with a very fast initial growth rate, such as cottonwood (Populus deltoides Bartr. ex. Marsh) would provide forest structure and forest products at a younger age than most tree species. A species that provides timber products, mast production or wildlife habitat at later ages could be intercropped with the cottonwood. Relay intercropping occurs when species are grown together for part of the rotation of either species. Maintenance of a more diverse overstory is not an objective of relay intercropping.

In contrast, commercial timber species could be intercropped with species of smaller stature that are beneficial to wildlife, provide showy flowers, or fix nitrogen. Suitable species include dogwood (Cornus florida L.), red mulberry (Morus rubra L.), persimmon (Diospyros virginiana L.), or black locust (Robinia psuedoacacia L.).

Mixed Monotypes

In mixed monotypes, a plantation is divided into patches containing a single species. These patches may be rectangular, or irregularly-shaped areas within the plantation. When mixed plantations are desired, but little information is available regarding relative growth rates and competitive ability of the desired species, mixed monotypes is the most sure way of establishing mixed-species forests.

True Mixtures

True mixtures are the most difficult type of plantation to maintain because success is unlikely unless species selection and

planting arrangement are appropriate. None of the commercially-valuable southern hardwoods will maintain good stem form and the capacity to grow well if they remain in an inferior crown position for many years. A haphazard planting of several species will likely create a stand where some of the species do not contribute to the mature stand and thus cost of planting and subsequent management for those species is wasted. Characteristics of the growth patterns of the species must be considered.

Augmenting the Mixture

Regardless of the type of mixture, it may be augmented by planting a different species in meandering rows or irregularly-spaced patches. The supplemental species may be desirable as a wildlife food or some other factor rather than as a commercial timber species.

Habitat Variability = Greater Diversity

Greater overstory diversity may be obtained by identifying site differences and matching species to site. On recent agricultural land, site differences will be reflected in the agricultural crop.

Stand Tending

Subsequent thinnings may be required to create a mature stand that maintains an even mixture of species. Such thinnings provide an opportunity to affect stand structure and species composition.

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Table 1. Attributes of different types of mixed-species plantations.

Type	Primary Competition	Advantages	Disadvantages
Intercropping mixtures	Various, Interspecific competition may only occur for part of rotation.	Multiple products	Overstory largely monospecific. Management for one crop likely to be disadvantageous for other crop.
Mixed monotypes	Intraspecific	Easiest to produce	Monoculture at small scale.
True mixtures	Interspecific	Natural appearance	Care necessary in species selection. Difficult to maintain all species in overstory.

PLANNING AND PLANTING CONSIDERATIONS IN THE BOTTOMLAND HARDWOOD REFORESTATION OF FLOOD-PRONE AGRICULTURAL FIELDS

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The significant decline of bottomland hardwood wetlands (BLH) acreage caused primarily by agricultural activities has resulted in the loss of important wildlife, water quality, and recreational functions. The interest in restoring these functions has led to an increase in returning unproductive, flood-prone agricultural fields back to BLH. The results from the US Army Corps of Engineers Wetlands Research Program studies conducted in the Mississippi Delta Region have provided information on key BLH restoration topics such as matching tree species to the site, what planting stock type to use, and post-planting cultural practices. For example, soil texture and structure may require the planting of flood-tolerant tree species on hydric soils even though hydrologic modifications suggest dryer conditions. The use of container planting stock may provide an improvement in early field survival on flood-prone areas and extend the planting season beyond the spring floods. The proper planning, including on-site knowledge of soil and hydrologic conditions, knowing the silvics of the desired tree species, and good planting techniques will enhance the chance of reforestation on flood-prone agricultural fields.

VEGETATION AND WILDLIFE COMMUNITIES ASSOCIATED WITH EARLY SUCCESSIONAL BOTTOMLAND HARDWOOD RESTORATION

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Abstract

We studied the relationship between vegetation and selected wildlife communities at the Lake George Reforestation Project (LGRP) in the Delta region of Mississippi from spring 1991 through summer 1992. The 3,600 ha area which had been cleared for farming, is being taken out of production incrementally and planted with bottomland hardwood species, primarily oaks (Quercus spp.), green ash (Fraxinus pennsylvanica), and baldcypress (Taxodium distichum). The area is characterized by ridge and swale topography and although subject to backwater flooding, higher areas seldom are inundated. Several large borrow pits pond water for much of the year.

Herbaceous species, including grasses, forbs, and vines colonized the site during the first year. Total canopy cover approached 100 percent over most of the area; a few of the wetter swales were sparsely vegetated. Forty-three plant species were identified. Johnsongrass (Sorghum halapense), morning glory (Ipomoea spp.), cocklebur (Xanthium strumarium), trumpet creeper (Campsis radicans), sesbania (Sesbania macrocarpa), and ladies eardrops (Brunnichia cirrhosa) were the dominants during 1991. By the next summer, asters (Aster spp.) and goldenrods (Solidago spp.) had replaced some of the above as dominants. Species composition varied with slope position; for example, Johnsongrass typically was found on the ridges while ladies eardrops was found most often in swales. Total plant cover and number of genera did not differ with slope position either year ($P>-0.05$). Vegetation in swales was shorter than on ridges and slopes ($P<-0.05$). There was little invasion by woody species; trees planted were less than 1 m tall and provided minimal habitat value.

Line-transect surveys in winter, spring, and summer yielded a total of 47 bird species. The most abundant breeding birds were the red-winged blackbird (Agelaius phoeniceus) and dickcissel (Spiza americana). Both were distributed throughout the area with densities per ha averaging 10.7 and 3.8 respectively in 1991; and 3.0 and 6.1 in 1992). Two unexpected nesting species were the mourning dove (Zenaida macroura) (N=15) and brown thrasher (Toxostoma rufum) (N=1); both nested on the ground. The winter

community was dominated by the red-winged blackbird, song sparrow (Melospiza melodia), swamp sparrow (M. georgiana), and savannah sparrow (Passerculus sandwichensis). Densities were 6.3, 8.7, 3.8, and 3.2 per ha respectively. The red-tailed hawk (Buteo jamaicensis), American kestrel (Falco sparverius), and northern harrier (Circus cyaneus) were the most numerous raptors. Other groups included short-distance migrants [American woodcock (Scolopax minor)] and neotropical migrants [common yellowthroat (Geothlypis trichas)]. Wading birds were abundant in areas that ponded water. Most birds that we could calculate density values for were more abundant on ridges and slopes ($P<-0.05$).

A total of 18 mammal species were identified. In summer 1991, only three small mammals were captured during 500 trap nights. One year later, populations had increased markedly and 183 individuals were captured in 880 trap nights. The cotton rat (Sigmodon hispidus) was the most abundant species. Others included eastern harvest mouse (Reithrodontomys humilus), cotton mouse (Peromyscus gossypinus), rice rat (Orzomys palustris), house mouse (Mus musculus), and Norway rat (Rattus norvegicus). No differences in abundance were found among plant communities ($P>- 0.05$). Scent station surveys revealed that the eastern cottontail (Sylvilagus floridanus) and nine-banded armadillo (Dasypus novemcinctus) were the most abundant medium-sized mammals. Coyotes (Canis latrans) and white-tailed deer (Odocoileus virginianus) were commonly observed.

The mosaic of plant communities resulting from the site's variable topography, and presence of open water contributed to the LGRP supporting numerous species of wildlife associated with early successional and aquatic habitats. Populations of several open-land birds using the LGRP (savannah sparrow, dickcissel, northern harrier) apparently have declined in recent years. Because similar habitat is uncommon in the Delta and most other parts of the Southeast, decision makers should consider managing portions of the LGRP for herbaceous and shrub communities for the maintenance of regional biodiversity.

SESSION RE8

RESTORATION, PROTECTION, AND CREATION: VERNAL POOL CREATION AND RESTORATION

Dr. John J. Zentner, Chair

TECHNOLOGICAL ADVANCES IN VERNAL POOL DESIGN AND CONSTRUCTION TECHNIQUES

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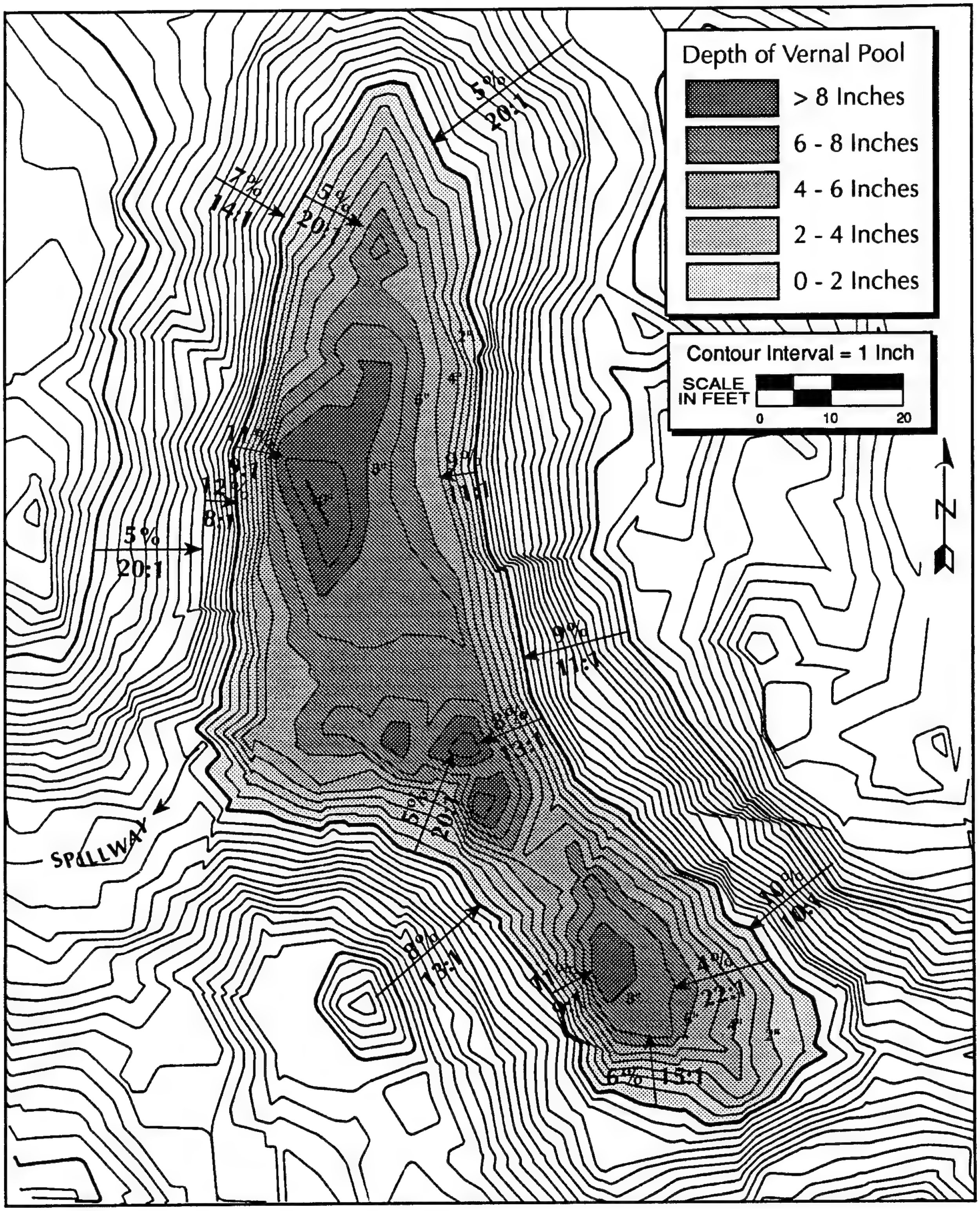
Vernal pools are depressional wetlands that inundate during the winter rainy season, desiccate in the spring, and remain dry the remainder of the year. These wetlands are found among the grassland communities of California with greatest concentrations occurring along the Central Valley's eastern terrace. Endemic plant species typically dominate the pools.

Sugnet & Associates has constructed over 900 vernal pools as compensatory mitigation to comply with Section 404 of the Clean Water Act. Constructed pools range between <O. 0 1 and > 1. 5 acres. Technological advances in pool design and construction techniques have allowed creation of vernal pool systems that successfully replace functions of historic pools.

Sites that historically supported vernal pools offer the highest probability of success for vernal pool mitigation, and provide desirable restoration opportunities. Suitable sites are identified through analysis of aerial photographs, soil maps and databases, topographic maps, and field reconnaissance. Soil profile analysis provides further site suitability information. Test pits permit a soil scientist to evaluate exposed soil profiles. Data assessing soil depth to impervious subsurface layers, permeability rates, and soil texture and structure are recorded to document the soil's capacity to pond water seasonally and to establish the appropriate excavation depth for subsequent inundation. Test pit locations are digitized into the CAD site map, and cross sections are generated showing soil horizons.

Analysis of data regarding topographical variances, hydrologic regimes, and biological heterogeneity of historic pools is used to define the parameters of compensation pools. In addition, surveying equipment and digital terrain models are used to develop detailed one inch (I ") micro-topographical maps. These maps aid in pool design by providing information on historic pool


Depth of Vernal Pool
> 8 Inches
6 - 8 Inches
4 - 6 Inches
2 - 4 Inches
0 - 2 Inches
Contour Interval = 1 Inch
SCALE IN FEET
0
10
20
N
SPILLWAY
5%
20:1
7%
14:1
9%
11:1
6%
15:1
8%
13:1
4%
22:1

depth, slopes and bottom contours. (Figure 1). Engineering software provides earthworm calculations including cut/fill volumes. Spreadsheets aid in water budget analysis ensuring pools meet hydrologic success criteria given specific watershed locations and soil restricting capacities. The sum of this information is then used to develop detailed grading plans, including soil profiles, cross sections, layout, construction methods, and pre/post grading topography.

During implementation, stake plots allow for precise pool placement within the landscape. Earth moving equipment excavates pools to specified grades within tolerances $\leq$ 0.5", verified with laser leveling equipment. Soil from the donor vernal pools (containing wetland seed, organic material, and encysted eggs of aquatic invertebrates) is used to inoculate created wetlands. Upland areas are vegetated by hydro/broadcast seeding of native/naturalized species and/or replacement of upland seed bearing soil removed during excavation. Cartographers produce as-built drawings by digitizing pool inundation and hydrophytic vegetation boundaries from enhanced digital aerial photographs.

Vernal pool mitigation has advanced significantly in the past 6-8 years. Properly designed and implemented mitigation plans have demonstrated that pools can function to meet hydrologic and biologic success criteria (Coe 1994). Proper application and continued refinement of technological advances in pool design and construction will promote the establishment of high-quality wetland systems.

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CONSTRUCTION RIPARIAN LANDSCAPES: SOIL CONSIDERATIONS

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I will discuss the role of soils in constructing riparian landscapes, with examples primarily drawn from central California. Most soils within the riparian zone can be divided among the following categories:

(1) **recently deposited soils**, which are relatively permeable, alluvial soils deposited along the banks of existing or former

waterways (further divisible between sand and gravel and loams);

(2) **isolated soils**, which are relatively impermeable soils typically deposited in basins outside waterways;

(3) **unrelated soils**, which are typically old soils formed under non-fluvial conditions that now host waterways, ranging from extremely impermeable soils (e.g., containing hardpans) to extremely permeable soils (e.g. aeolian deposits); and

(4) **modified soils**, which are soils that have been redeposited in or adjacent to waterways by artificial actions and are usually highly permeable due to mixing but may have impermeable lenses.

Modified soils are different from unrelated soils in that soil conditions can change significantly both vertically and horizontally in relatively short distances. Erodability and transportability (processes that strongly influence channel formation) varies in accordance with the chemistry and weight of the soil and generally correlate with permeability, which strongly influences vegetation dominance. Generally, for sands and gravels, erodability is high but transport is slow due to the poor cohesiveness and high weight. These soils typically form broad, shallow washes and, in the west, riparian vegetation is dominated by deep-rooted trees, such as the California sycamore (Platanus racemosa).

Loams have higher clay contents that sands and gravels with a corresponding reduction in erodabilty and permeability but an increase in transportability. These conditions result in the "classic" multi-stage channel forms celebrated by geomorphologists. Vegetation is typically dominated by trees and is distributed among two to three terraces, often in discernible patterns relating to depth to summer water but also as a result of somewhat extraneous factors---propagule arrival and survival, episodic events such as slope failures or landslides. The lowest terrace in these soils (roughly between the summer water level and the mean annual flood) is typically dominated by willows (Salix spp.) and cottonwoods (Populus spp.), the middle terrace (roughly the mean annual flood line to the 10-year event line) by mid- to tall-statured trees like the Oregon ash (Fraxinus latifolia) or the box elder (Acer negundo), and the high terrace dominated by large, heavy seeded species such as the valley oak (Quercus lobata), the signature tree of California's Central Valley riparian community.

Less permeable soils have less erodability and permeability but much higher transport rates. Consequently, channels are either swales, where no radical downcutting or uplifting has occurred, or vertical-banked channels. Due to the relatively low permeability, vegetation is often dominated by herbaceous species (e.g., various members of Juncaceae) and not trees, especially where summer drought conditions make tree survival unlikely. Where enough

summer water occurs, one of the arid west's only swamp habitats occurs, dominated by buttonbush (Cephalanthus occidentalis), one of the few riparian species the West shares with the remainder of the United States.

Soil conditions should strongly influence the selection of an appropriate channel form and plant palette for riparian construction projects. Where conditions exist that are inimical to growth of the target vegetation, soil modifications can be considered but only subsequent to appropriate identification and understanding of the project site soils.

VERNAL POOL CREATION
PETALUMA FACTORY OUTLET VILLAGE

Richard Nichols, Margaret Baumgratz , and Richard Meredith

Conditions of project approval required replacement of a degraded seasonal wetland on a proposed shopping mall site with higher value vernal pools on an adjacent parcel. The existing wetland on the project site was a swale on impermeable clay soils which ponded with rainwater in the winter and dried through evaporation by early summer. Due to a history of disturbance from disking and other agricultural practices, the existing wetland was dominated by non-native vegetation such as cocklebur (Xanthium strumarium) and Italian ryegrass (Lolium multiflorum). However, a few small patches of native species typical of vernal pools such as downingia (Downingia bicornuta) and bracted popcorn flower (Plagibothrys bracteata) occurred on the site.

Although vernal pool construction projects had never been implemented in the Petaluma Valley (about 40 miles north of San Francisco), the viability of created vernal pools had been demonstrated by several projects in the Sacramento Valley (about 50 miles east of the project site) and in the Santa Rosa Plain (about 10 miles north of the project site). Although some of these projects are indicating successful attainment of mitigation performance criteria as much as 7 years after creation, there is much controversy regarding long-term viability. Literature reviews and consultations, however, indicate that success was primarily dependent on attaining wetland hydrology and that the substrates on the project site and vicinity (Clear Lake clay soil series) facilitated achievement of the required ponding due to their highly impermeable nature.

An appropriate mitigation site for the project was found on an adjacent parcel which was underlain with Clear Lake clay soils and met other mitigation criteria such as minimal existing habitat values, and presence of adjacent undeveloped areas as buffers. An

"ecosystem" approach was proposed which consolidates existing seasonal wetland habitat, upland buffers enhanced by plantings of native shrubs and grasses, and restored riparian corridors surrounding the constructed vernal pools (Figure 1). Following negotiations with the land owner, a conservation easement was deeded on the property to protect it in perpetuity.

Soil borings were taken in three locations of each proposed pool at various depths down to 6.5 feet below existing grade. Laboratory permeability tests showed permeability rates ranging from 3.6×10^{-7} to 7.5×10^{-9} centimeters per second at depths of 1.5 feet to 3.0 feet below grade. A conservative hydrological analysis was conducted by Mitch Swanson and Associates which demonstrated that pools properly excavated would maintain standing water from direct rainfall (without considering adjacent run-off) in normal rainfall years from December through March, which is similar to the hydroperiod for natural vernal pools (Fugro-McClelland 1993). This data convinced skeptical regulators that the mitigation had a good chance of success.

Mitigation implementation commenced in November of 1993, coincidal with project construction. The pools were excavated as specified in the grading plan (Figure 1) under supervision the of Fugro biologists in the fall of 1993. Vegetation and topsoil from the small areas dominated by native vernal pool species on the project site was stockpiled and spread over the constructed pools. Most of the pool areas were inundated through direct rainfall and adjacent run-off from December 1993 through May 1994, although small areas of two pools were subsequently excavated deeper based on observations of shallow or no inundation.

Native wetland species, such as downingia (Downingia spp.) and button-celery (Eryngium aristulatum), colonized the pools from transported soils, but invasion by non-native hydrophytic vegetation was determined to be a problem. Preliminary sampling along transects bisecting each pool showed attainment of less than half the performance criteria of at least 60 percent relative cover of natives, although attainment of cover criteria for hydrophytic vegetation in general was attained. Much of the cover was composed of swamp timothy (Crypsis schoenides), a highly invasive stoloniferous wetland grass. Several aggressive weed control efforts by hand and with herbicide (wetland approved) were conducted during the summer and fall of 1994. To augment colonization by natives, pools were seeded with native vernal pool species collected from natural pools in the vicinity such as bracted popcorn flower (Plagiobothrys bracteatus) and California semaphore grass (Pleuropogon californicus) in the Fall of 1994. Facultative native perennial grasses such as creeping wildrye (Elynus triticoides) were planted around the margins of the pools and plugs of spikerush (Eleocharis palustris) were planted in the deepest portions of the pool.

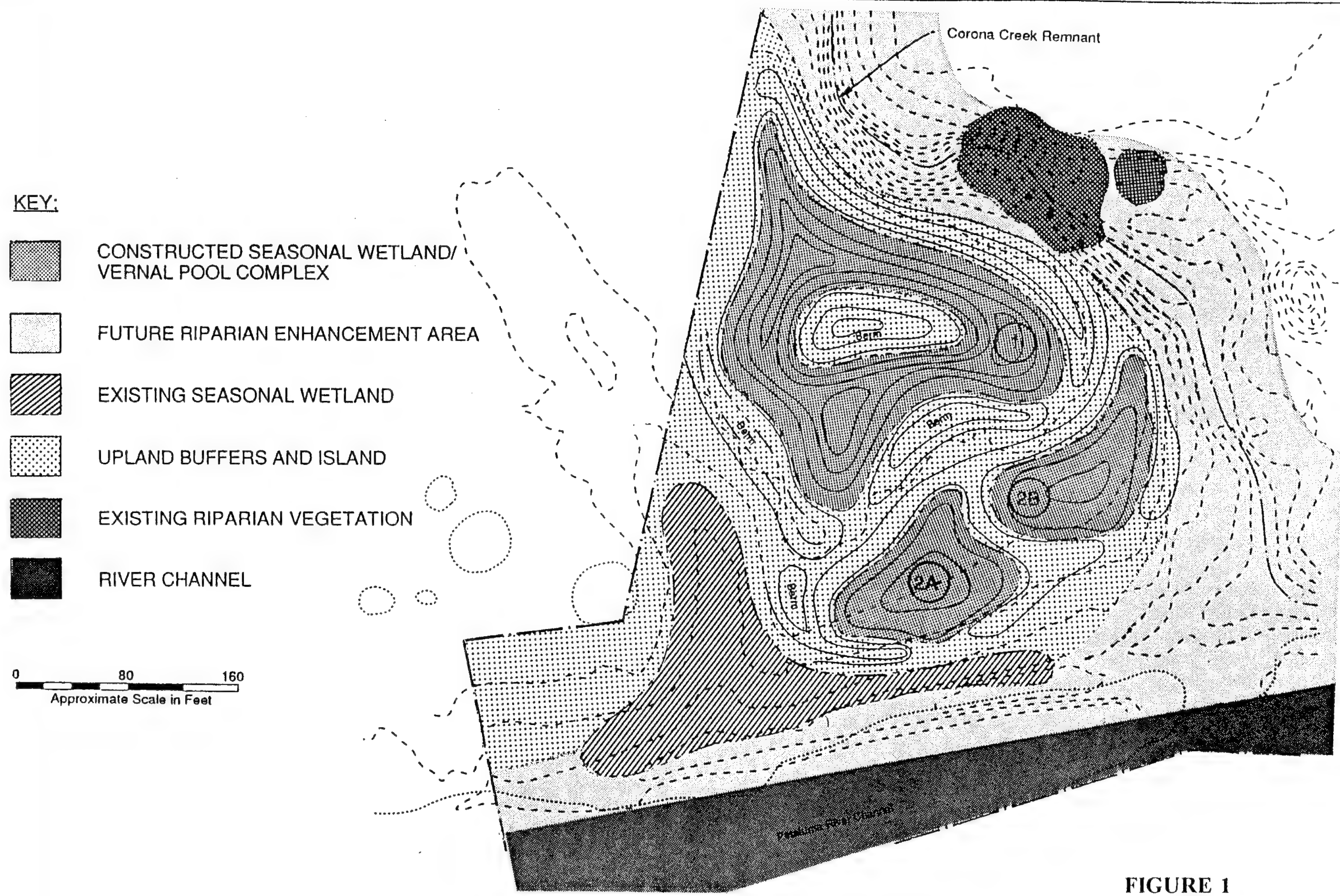

FIGURE 1

Petaluma Factory Outlet Village
VERNAL POOL MITIGATION PLAN

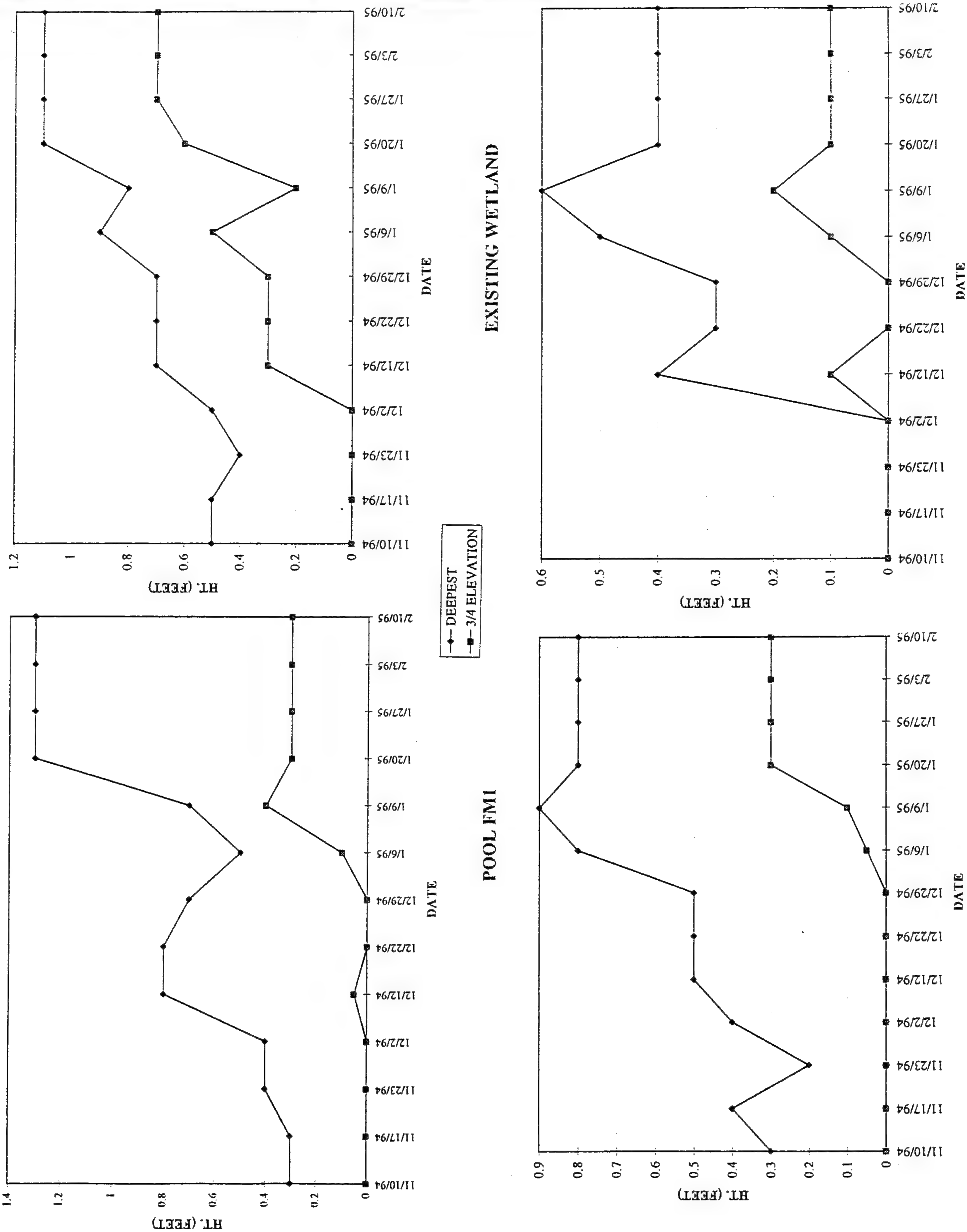

FIGURE 2

Hydrographs of constructed vernal pools compared with existing wetland

Staff gauges were installed in the pools at the deepest location of each pool and the 3/4 full elevations (Figure 2). Monitoring of the gauges in the winter of 1994-1995 indicated successful attainment of the hydrological criteria of prolonged inundation.

With continuing timely and intensive weed control efforts in the next few years, these pools are well on their way to successful attainment of performance criteria, and based on observations of wetland dependent wildlife use, have more than replaced the values of the wetland on the project site.

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A MULTI-OBJECTIVE WETLAND CREATION STUDY ON THE LOS ANGELES RIVER AT THE TAYLOR RAILROAD YARD

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The Los Angeles River continues to be a topic of interest for flood control planners, engineers, and environmental scientists. The 51-mile-long concrete channel that provides flood protection to many of the 8 million residents of Los Angeles County has recently been at the center of controversy in an effort to environmentally retrofit the river with wetlands, riparian corridors, recreational development, and water conservation and water quality features. Efforts by local interest groups to return the Los Angeles River to a natural floodplain with wetland functions and values typify a new federal emphasis on non-structural solutions to flood control problems.

This study was conducted for the US Army Corps of Engineers, the Los Angeles County Department of Public Works, and the Department of Water Resources to evaluate the feasibility of using the Taylor Railroad Yard, a 174-acres parcel currently being offered for sale, as a location along the Los Angeles River for a multi-purpose wetland creation project. The site offers the combined potential for flood control detention, low flow diversions to create wetlands and riparian habitat, water quality improvement of lateral storm drain flow, and construction of passive and active

recreation facilities. The opportunities and constraints of several alternative configurations are analyzed in terms of the hydrology, hydraulics, geomorphology, sediment transport, and groundwater that exists at the site.

A recommended plan was developed that maximizes project opportunities and minimizes the effect of site constraints such as pre-existing storm drain alignments, power line towers, required railway rights-of-way, and localized soil toxicity. The primary project benefit includes removal of the 100-yr overflow area that currently exists along this section of the Los Angeles River. It would also provide water quality improvements to the surrounding urban run-off in compliance with the NPDES Program, and provide significant habitat value through riparian and wetland enhancement.

PROPER VERNAL POOL SITING AND CONSTRUCTION PRACTICES

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Vernal pool compensation is viewed skeptically by state and federal resource agency personnel. Three critical reasons for skepticism are poor site selection, pool design, and construction practices. Vernal pools have been constructed on steep slopes, on soils with no impervious subsoil, on fill, and virtually abutting active channels. They have been designed with insufficient topsoil, outcropping hardpans, no outlet barriers, leaky or completely sealed side slopes, adjacent spoil disposal, or in other ways that can prevent desired pool hydrologic function. Unsupervised construction also introduces opportunities for failure. Rigorous physical site investigations were undertaken at a site near Roseville, CA, to minimize the potential for failure. Subsequent construction supervision permitted avoidance or modification of fatal site conditions unencountered during design. This paper presents the design methods and construction practices and illustrates, by example, the conditions encountered during construction that may well have caused failure were the contractor allowed to work unsupervised.

SESSION CP4

CRITICAL PROCESSES: WETLAND HYDROLOGY

Jack E. Davis, PE, Moderator

HYDROLOGICAL PROCESSES MAINTAINING A RIPARIAN WETLAND

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The water budget of a freshwater, nontidal marsh on a tributary of the Chesapeake Bay was dominated by surface water (95% of input, 98% of output). Groundwater input was limited by the low hydraulic conductivity of the material underlying the marsh and by the low head gradients that develop. The wetland was flooded in winter and spring by overbank flow. Sixteen brief floods (<2 days duration) during the 1992 growing season provided recharge and resaturated the marsh sediments (Figure 1). During the winter, the run-off/rainfall ratio is higher downstream of the marsh than upstream suggesting that in the winter, the wetland increases flooding (Figure 2). In the summer, the volume of storm run-off leaving the marsh is less than that coming into the marsh because of storage within the marsh.

NUMERICAL MODELING OF WETLANDS HYDROLOGY, HYDRAULICS, AND SEDIMENTATION

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Introduction

The objectives of wetland management are often at odds with the land use objectives of the adjacent property owners and with competing users of the wetland water course. The long term success of restored and created wetlands will depend upon our ability to manage these systems within the confines and restrictions of the managed surroundings. The management of wetlands is further complicated by the physical, chemical and biological interactions that make up a functioning wetlands Management measures can have

unexpected and undesirable long-term effects on the behavior of the wetland ecosystem if these processes are not well understood. Tools that allow managers to predict the impacts of alternative management plans are preferred over trial and error methods.

Models are predictive tools that are used to test the effects of alternative inputs on system behavior. Numerical models can be used to predict the behavior of water and sediment in wetland regions under alternative management proposals.

Methods

Numerical models for wetland surface flows are being used to design and manage wetland restoration and creation projects. The technology for simulating wetland surface flows is based on the solution of the equations for shallow water flow with some important modifications that allow one to properly simulate intermittent flooding and flow through emergent vegetation. A variety of numerical hydrodynamic modeling tools with different capabilities are commercially available. Therefore, it is important to understand what assumptions have been made in the model formulation to determine if the model is suitable for a particular wetland application. In this presentation the Army Corps of Engineers model for wetland surface flows is described, the capabilities and limitations of the model are discussed, and several example applications are presented.

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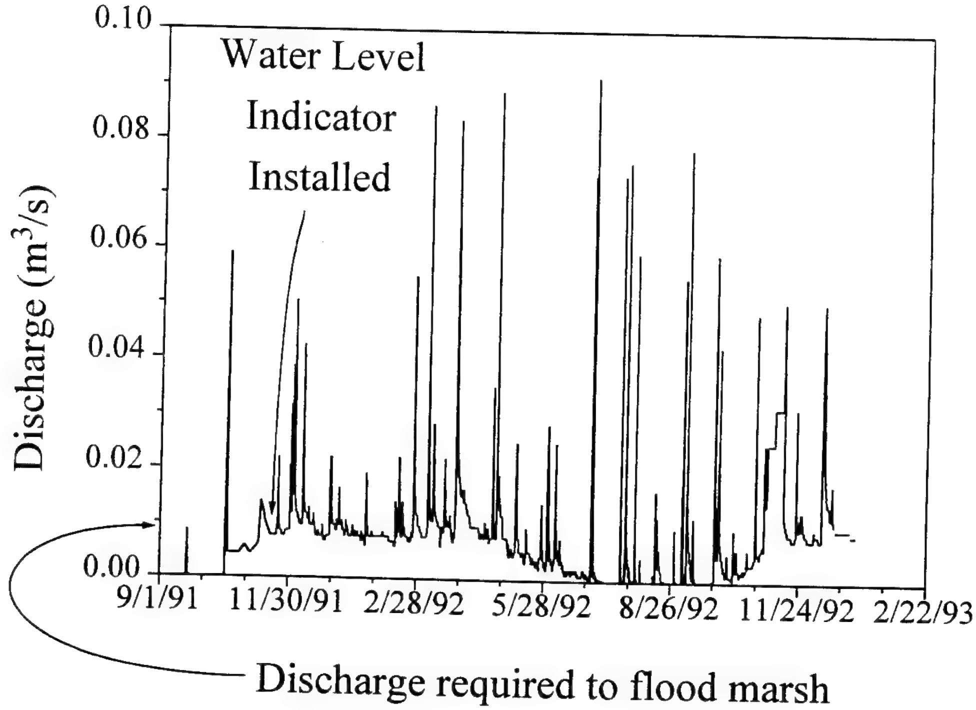

Figure 1

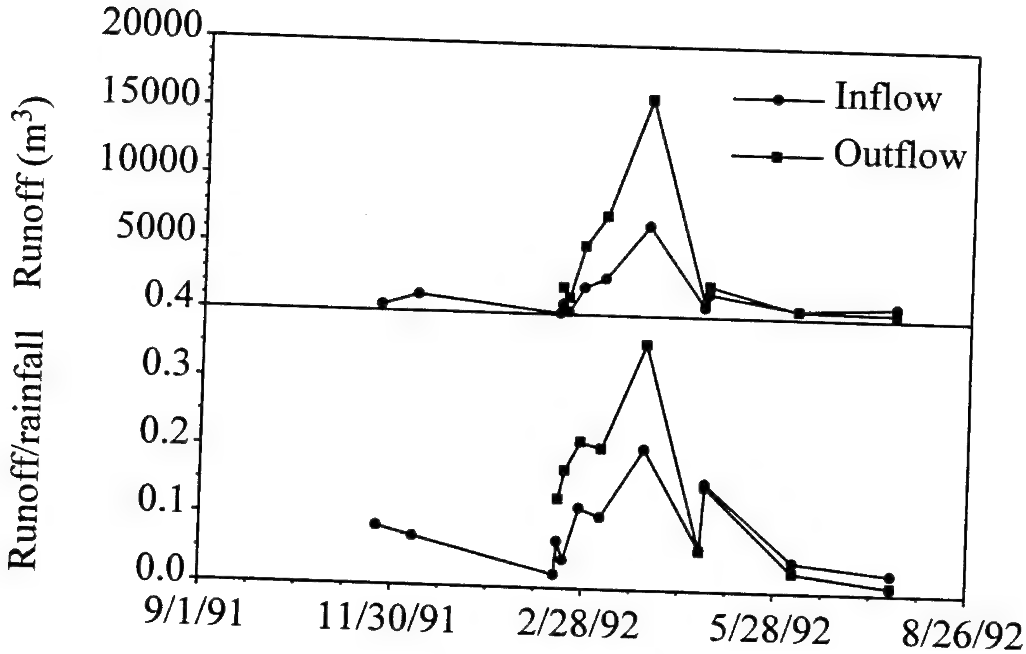

Figure 2

FLOOD MITIGATION IMPACTS OF A FRINGE WETLAND

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The role of wetlands in flood mitigation is not fully understood due to the complexity of the hydrologic characteristics. To begin to assess the impact on flood events a simple system is modeled. Discharge from an upstream basin is assumed flow through a riverine wetland. The wetland is modeled using Muskingum-Cunge flow routing in HEC-1. A sensitivity analysis was then completed to study the effects of various wetland and upstream basin conditions.

Several findings were developed. First, as many hydrologists suggest, the benefits of a wetland diminish as the magnitude of the event increases. Second, the for same peak flow, increasing event duration also adversely affects the flood reduction impact. Finally, the physical characteristics of the wetland have a significant impact on flood reduction. Thus, conclusions about the magnitude of the impact at a specific site must be determined and analyzed with a detailed analysis. Future work to complete these analyses is recommended.

SIMPLE MODELS OF FLOODPLAIN INUNDATION AND WATER TABLE FLUCTUATION FOR USE IN ECOLOGICAL RESEARCH

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Many ecologists and hydrologists working in floodplain wetland ecosystems would benefit from having access to long-term water table and flood inundation data for specific research or monitoring sites. However, well and river stage measurements are typically available for only a few sites along a river, often at considerable distance from study sites. Therefore, some method must be used to transfer information about river stages (or discharge levels) from longer-term monitoring gauges (such as USGS stations) to the study area of interest.

We have been testing an approach for developing simple empirical models of water table fluctuation and surface water inundation. Regression models are based upon available USGS stream-gaging data, supplemented with field data collected from

shallow observation wells and field surveys of river stage at differing water levels. This paper presents the results of our modeling effort along the Yampa River in Colorado.

SIMULATIONS OF A BLH USING THE WETLANDS DYNAMIC WATER BUDGET MODEL

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Wetlands Dynamic Water Budget Model

The Wetlands Dynamic Water Budget Model is based on a link-node modeling approach. The link-node method divides the wetland system into a series of finite volumes called "nodes" where water level or stage is defined. Flows between adjacent nodes are defined along one-dimensional channels called "links". The scheme is flexible because it easily represents simple and complex geometry. The approach makes representation of hydrologic inflows and outflows conceptually simple and the numerical formulation is efficient to solve. The model has three major modules - surface water processes, vertical processes, and horizontal groundwater flow processes - which account for channel and overbank flows, tidal forcing, riverine inflows, upstream basin flows, wind shear, flooding and drying, various bottom friction types, hydraulic structures, canopy interception and drainage, infiltration, surface water evaporation, soil water evaporation, transpiration and variably saturated horizontal groundwater flow. The model is described in detail in (Walton et al., 1995)

Model Applications

The model was developed and applied to support a large field investigation of wetland processes conducted in the bottomland hardwood wetlands of the Cache River floodplain between Patterson and Cotton Plant, Arkansas. The model augmented the field study's measured hydrologic data by filling temporal and spatial data gaps. The model data provided wetland researchers with good estimates of

hydrologic parameters (e.g. hydroperiod and flooding frequency) over large regions of the wetlands, allowing them to correlate the structure and response of the wetlands to those parameters.

The model was also used to explore wetland modification scenarios. Several scenarios were tested including the hypothetical construction of a highway crossing (using several designs to divert water through or over the structure), channelization of the river where levees constricted the floodplain and the channel was deepened, and the creation of wider floodplains through the hypothetical removal of levees. Construction of the highway crossing had a significant effect on upstream flood stages and durations but had a lesser effect downstream. Channelizing the river with levees increased the elevations in the river during flood events. Dredging had little effect on river stages during flood events, but made the stages during low-flow periods even lower. The third scenario created an about 2% more wetlands area in the lower reaches of the wetland. The additional wetland area resulted in an reduction of about 8% in wetland stages further upstream.

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SESSION SM4

STEWARDSHIP AND MANAGEMENT: CHANGE ASSESSMENT AND CUMULATIVE IMPACTS ANALYSIS

Mark R. Graves and Larry Waggoner, Co-Chairs

USE OF REMOTELY SENSED DATA TO MONITOR WETLAND EXTENT AND CHANGE NEAR CHOCTAWHATCHEE BAY, FLORIDA

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Introduction

Current satellite remote sensing technology has been examined extensively as a source for wetland monitoring and mapping and has been deemed insufficient when used alone for wetland delineation (FGDC 1992). Consequently, the U.S. Fish and Wildlife Service is using high-altitude color infrared aerial photography (1:58,000) for its National Wetlands Inventory Program (Wilen 1992). The Federal Geographic Data Committee (FGDC) Wetlands Subcommittee is currently evaluating alternative remote sensing technologies for monitoring wetland change and extent (FGDC 1994).

A Visiting Investigator Program project performed by Spectrum Sciences & Software, Inc. through NASA's Commercial Remote Sensing Program Office at John C. Stennis Space Center examined the use of multiple dates of Landsat Thematic Mapper (TM) data for measuring the cumulative extent of wetland loss or modification. In addition, high-resolution (10 m) airborne multispectral digital data were examined for their utility in providing a baseline measurement for wetland mapping.

Methods

The Choctawhatchee Bay area in northwestern Florida was selected for this project because it contains a variety of upland and wetland land cover types. In addition, the area is experiencing rapid land use development pressures.

Landsat TM data were acquired on July 19, 1986 and August 10, 1994. National Wetlands Inventory (NWI) data were acquired via Internet from the NWI Central Control Center in St. Petersburg, Florida. Calibrated Airborne Multispectral Scanner (CAMS) data and 1:24,000 scale true color aerial photography were acquired by NASA on November 20, 1992. A Normalized Difference Vegetation Index (NDVI) was computed on each of the TM data sets. A 256-class difference image was created by subtracting the 1994 NDVI from the 1986 NDVI. The difference was recoded into categories representing high, medium, and low biomass change. The change image and NWI data were cross tabulated to quantify the extent of wetland change from 1986 to 1994. Regions of abrupt vegetative change were identified and field investigations were conducted to assess the change detection results. The CAMS imagery and aerial photography were used in the field to assess their usefulness for vegetation type discrimination.

Observations

Preliminary results indicated extensive wetland loss within the study area. Wetland loss appeared to be greatest within the coastal regions experiencing intensive land use development. The multiple dates of Landsat TM provided a baseline understanding of the cumulative extent of wetland change in this area. The change detection techniques employed provided a quick method for assessing and quantifying land use trends. However, it is important to recognize regional and seasonal differences in wetland ecosystems. Techniques that may apply in this region may not apply in other regions (e.g., Prairie Pothole). Vegetation was assumed to be an integral part of Choctawhatchee Bay wetland regimes. Therefore, lack of vegetation for a particular area (e.g., low biomass on NDVI) where a wetland once existed indicated a change in wetland geography.

The change detection methods may not accurately identify wetland gain because of the spectral and spatial limitations of the TM data. The CAMS imagery appeared to be more useful than TM data for delineating vegetative boundaries, including small wetland patches. However, neither TM nor CAMS data provided the information necessary for discriminating between pine communities on well-drained and poorly drained soils. These observations are consistent with findings from a similar study by Provancha et al. (1994). While the high spatial and adequate spectral resolution used in this project may identify vegetation type, another accurate data source is needed to provide information regarding soil type.

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COMPARING WET TERRAIN UNITS, LANDSAT-TM AND NWI DATA, YUKON TRAINING COMMAND, FORT WAINWRIGHT, ALASKA

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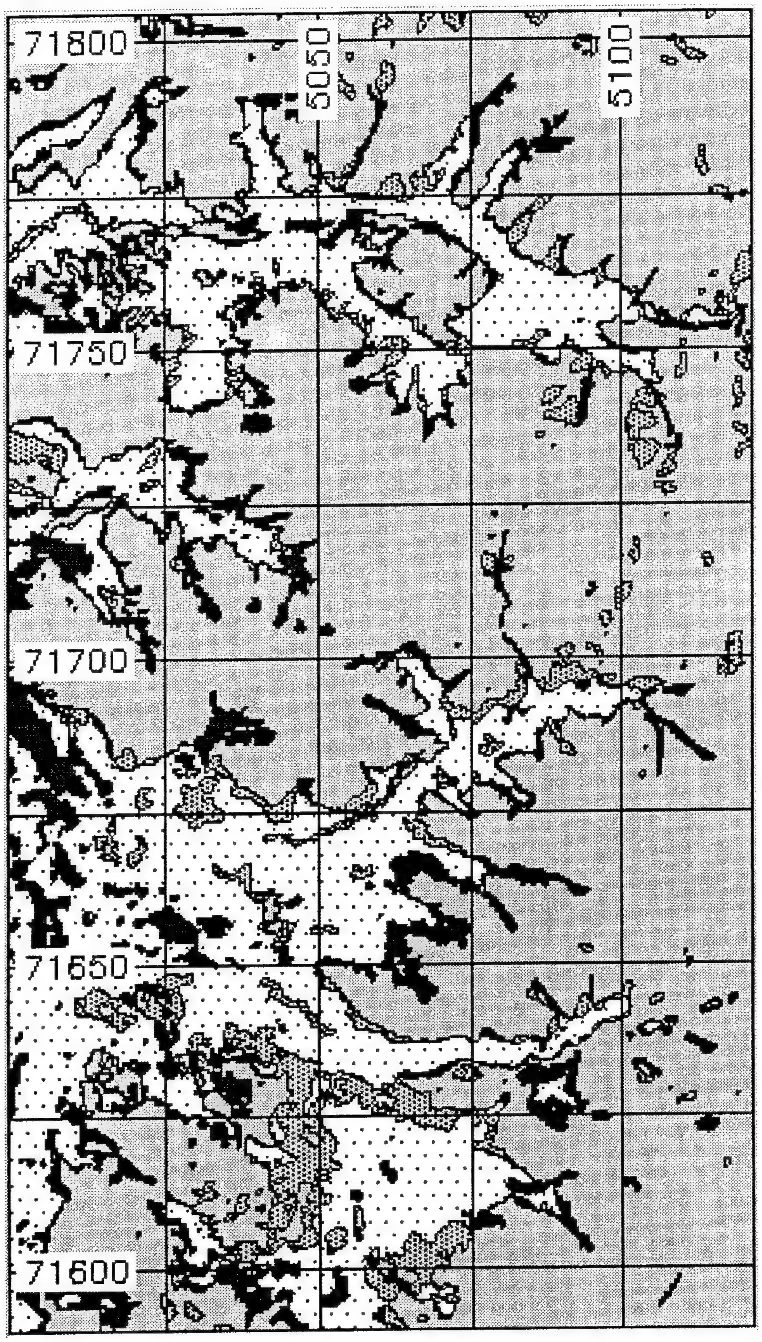
Military installations encompass undeveloped lands that have become increasingly important as wildlife habitats. Accurate natural resource inventories are needed to enable stewardship of these lands. As part of a project to integrate wetlands into the ITAM (Integrated Training Area Management) program for managing Army lands, wetland inventory methods were evaluated using existing digital geographic data of Ft. Wainwright's Yukon Command Training Site.

The Yukon Command Training Site lies within the discontinuous permafrost region and taiga forest where topographic position and fire history play strong roles in determining soil moisture, dominant vegetation and permafrost distribution. Eleven different 3-band or band transformations (Principal Components, Tasseled-Cap, and Normalized Difference Vegetation Index) were tried in unsupervised TM classifications of wetlands. Use of the thermal wavelength band (Band 6) together with green and near-IR wavelengths (Bands 2 and 4, respectively) provided the best agreement with the National Wetland Inventory (NWI) because apparent brightness temperatures of lowland wetland sites were warmer than upland forested sites.

The TM classification compared well (.67 Kappa Index of Agreement) with the NWI (Fig. 1). A wet terrain unit map we derived from a digital elevation model (DEM) agreed with the NWI (.64 KIA) nearly as well as did the TM classification (Fig. 2).

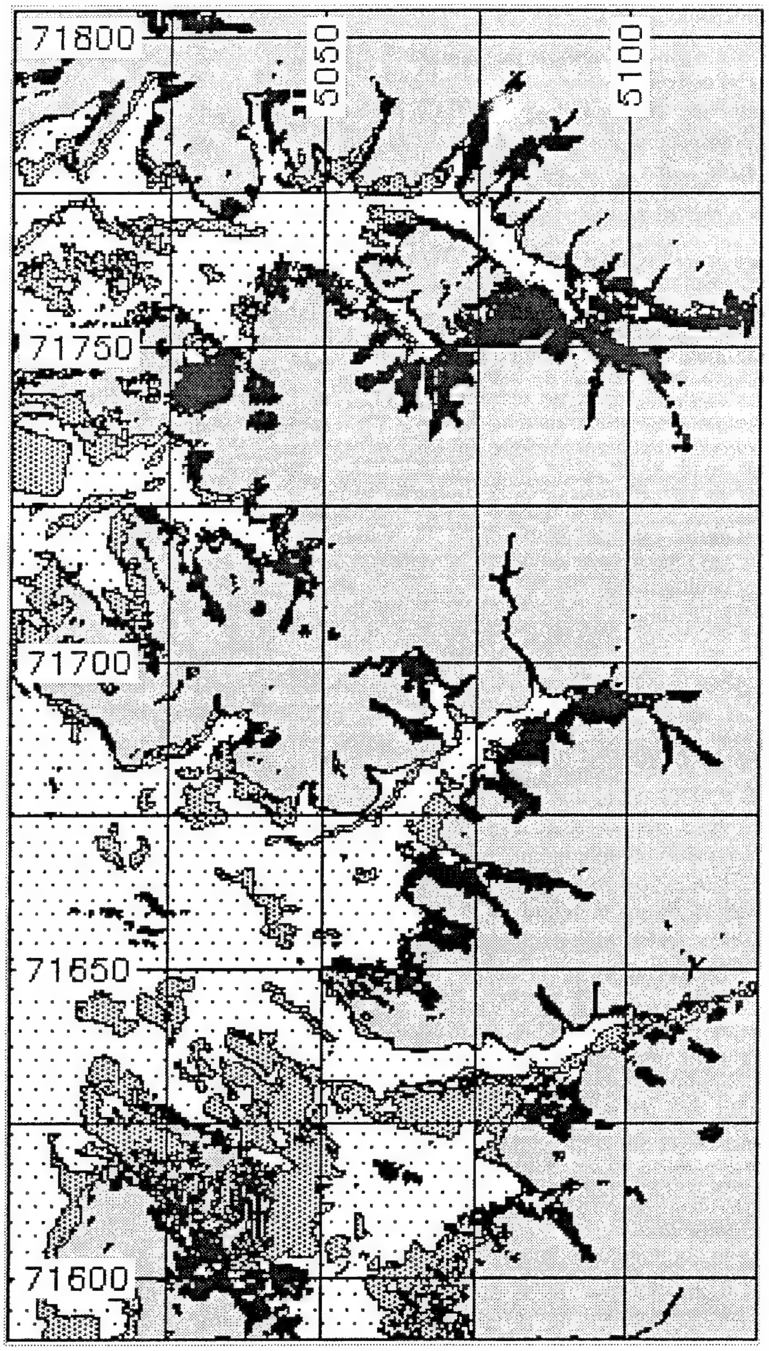
Ft Wainwright, AK (Fig. 1)
NWI wetland and Landsat TM data comparison



- Upland agree
- Wetland agree
- NWI upland / TM wetland
- NWI wetland / TM upland

(Fig. 2)

Ft Wainwright, AK
NWI wetland and wet terrain data comparison



Upland agree
Wetland agree
NWI upland / wet terrain
NWI wetland / not wet terrain

NWI's are of limited accuracy and become outdated. We recommend an installation's wetlands be accurately field mapped and then digitized and geo-referenced with satellite data. This approach would permit the resource manager to assess changes in vegetative vigor or moisture status within know wetlands. The synergism would provide an accurate and synoptic tool for wetland stewardship.

CUMULATIVE IMPACT ANALYSIS OF WETLANDS USING HYDROLOGIC INDICES

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Abstract

A hydrologic analysis of historic stream data collected with the gage on the Cache River at Patterson, Arkansas, USA, is presented as the basis for cumulative impact analysis of riverine wetlands, Subtle, long-term changes in hydroperiod which could collectively have major impacts on wetlands functions are quantified, Harmonic analysis, time-scale analysis, and conventional methods of hydrologic analysis of gage data at decade intervals show a steady decline in the magnitude and predictability of the base flow during low flow periods from the decade of the 1920's and becoming increasingly more pronounced into the 1980's. Hydroperiod alterations may be associated with increased groundwater pumping to support rice agriculture in the basin, These hydrologic methods are simple enough for routine application (when adequate data are available) but sufficiently sophisticated to identify subtle changes in hydroperiod associated with cumulative impacts. They have the potential to explain changes in biotic communities or wetlands structure as part of comprehensive wetlands studies.

DEMONSTRATING THE IMPACTS OF INCREMENTAL LANDSCAPE CHANGES ON CACHE RIVER HYDROLOGY

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Cumulative impacts to Cache River hydrology were assessed by

integrating hydrologic analyses with a review of historical land use changes in the basin. Approximately 80% of the bottomland hardwood forest in the Cache River basin was converted to cropland by the late 1960s (MacDonald et al. 1979). In 1975, rice acreage controls were lifted, followed by a dramatic increase in the acreage of this highly water-dependent crop. A 10 m decline in groundwater elevation has been attributed to pumping for rice irrigation from the alluvial aquifer (Engler et al. 1945; Broom and Lyford 1982). This study documents several significant impacts to Cache River flows that have resulted from both the incremental conversion of forest to cropland and the growth of rice agriculture in the basin.

Flow-exceedence analyses revealed an increase in extreme low flows (<10 cfs) and less frequent moderate (<100 cfs) low flows in recent years (Figure 1). Both of these findings are consistent with impacts from rice agriculture practices. The increase in extreme low flow frequency coincides with the growth of rice agriculture. The magnitude of yearly groundwater drawdowns was positively correlated with rice acreage and was unrelated to rainfall. Thus, the decrease in annual minimum flows may reflect the loss of a stabilizing influence historically provided to the river by groundwater discharge.

A decrease in the frequency of moderate (< 100 cfs) low flows is also consistent with rice farming practices, specifically the drainage of rice fields into surface water ditches at the end of the summer, which is historically the low flow season. The addition of this agricultural drainage during the low flow season reduces the number of days each year flows fall below 100 cfs.

There is no evidence that a change in climatic conditions accounts for the observed hydrologic changes. In fact, multiple regression analyses indicate the relationship between climate (represented by average monthly rainfall, antecedent rainfall, and temperature) and flow is weakest in more recent decades when extreme low flows were more prevalent. Low flows in the summer (when rice irrigation occurs) were least associated with climate in most recent decades.

Groundwater pumping for rice irrigation is strongly implicated as the underlying cause of more frequent extreme low flows based on the concurrent decreases in extreme low flows and increases in rice acreage (Figure 2), the lack of climatic association with flows in latter years, and the positive correlation between groundwater drawdown and annual rice acreage. Increases in flows that were observed for August and September are also consistent with rice farming practices, reflecting the contribution to natural drainages of water drained from rice fields at the end of the summer. Results of this study illustrate the importance of applying several analyses or indicators in hydrologic cumulative impact assessments.

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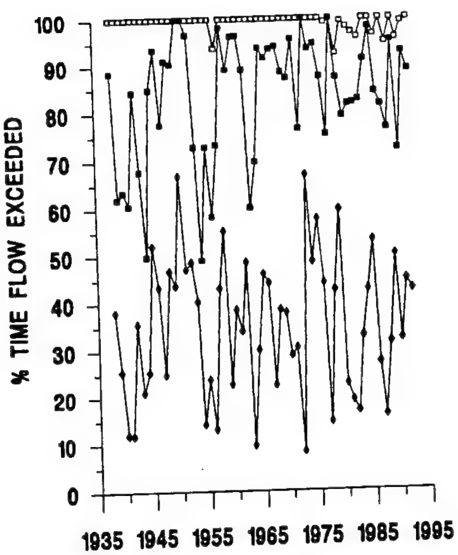

Figure 1. Percent of time flows exceeded 10 cfs (open squares), 100 cfs (closed squares), and 1000 cfs (closed diamonds).

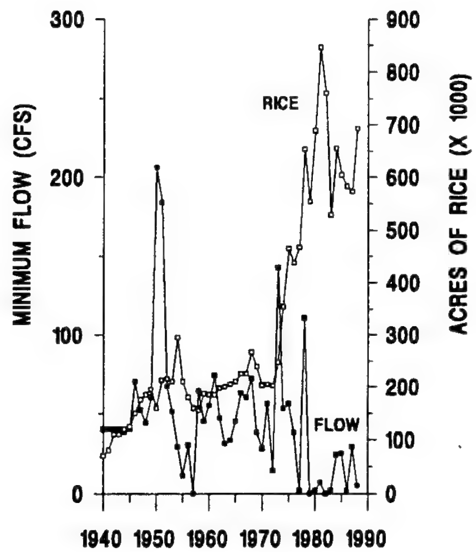

Figure 2. Long-term trends in annual minimum flows and rice acreage.

SESSION MB1

MITIGATION AND MITIGATION BANKING:
EFFECTIVENESS OF MITIGATION
Ms. Kathy Ryan, Chair

MITIGATION OF PERMITTED WETLAND IMPACTS IN NORTH CAROLINA

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Wetland development in North Carolina is regulated under Section 404 of the Clean Water Act, as well as the state's Coastal Area Management Act (CAMA) and Dredge and Fill Act, Permits issued under these laws require developers to avoid, minimize and often compensate for wetland impacts, This paper summarizes the results of a study documenting the effects of management decisions on the state's remaining wetland resource and the adequacy of mitigation practices required in those permits.

Information on 1,768 wetland development projects requesting Section 404/401 authorization during a three year period (1991-1993) was compiled from state environmental agencies and Corps of Engineers, Wilmington District permit files and databases, only projects impacting vegetated wetlands were included.

Evaluation of the permit record revealed that authorized wetland development activities affected an average of 717 acres of vegetated wetlands annually and led to the permanent loss of 507 acres per year, Of the 589 permit applications received per year, an average of 20 permits were denied or withdrawn by applicants, eliminating almost 300 acres of potential impact annually. In addition, mandatory avoidance and minimization further reduced permitted impacts by 95 acres per year.

An average of 20 permits per year, or four percent of the permits authorizing permanent wetland impacts, required compensatory mitigation. Compensation provided by these permits resulted in the creation (23%), restoration (25%), enhancement (2%) and preservation (50%) of 203 acres of wetlands annually, Overall, the amount of compensation provided offset only 40% of the total area permanently impacted, Moreover, greater than one- half of the total area provided as compensation was in the form of enhancement or preservation, neither of which increase the existing wetlands base, Therefore, despite the amount of compensation provided,

Table 1. Total permitted wetland impacts and compensation in North Carolina by permit type, 1991-93.

	Non-Compensatory Permits				Compensatory Permits		
	Temporary Impacts		Permanent Impacts		Permanent Impacts		Compensation Provided
Permit Type	No. of Permits	Area (acres)	No. of Permits	Area (acres)	No. of Permits	Area (acres)	Area (acres)
CAMA	1	77.1	138	38.2	14	13.7	17.4
Individual	0	0.0	93	133.9	24	298.4	518.8
GP 30[a]	0	0.0	3	0.2	0	0.0	0.0
GP 31[a]	0	0.0	11	4.2	2	3.8	12.2
GP 297[a]	7	363.5	0	0.0	0	0.0	0.0
NWP 3	0	0.0	15	3.1	0	0.0	0.0
NWP 7	0	0.0	6	2.6	0	0.0	0.0
NWP 12	186	191.2	0	0.0	0	0.0	0.0
NWP 13	0	0.0	15	4.9	0	0.0	0.0
NWP 14	0	0.0	233	42.0	0	0.0	0.0
NWP 16	0	0.0	0	0.0	1	3.3	7.6
NWP 18	0	0.0	65	7.3	1	0.02	0.02
NWP 23	0	0.0	44	15.2	4	4.5	4.7
NWP 25	0	0.0	1	0.3	0	0.0	0.0
NWP 26	0	0.1	546	811.2	16	46.7	47.5
LT 26[b]	0	0.0	271	86.1	0	0.0	0.0
NWP 33	5	0.6	0	0.0	0	0.0	0.0
TOTAL	199	632.5	1441	1149.2	62	370.4	608.2

[a] Regional general permits for use only in North Carolina.

[b] LT 26: "Less than NWP 26" refers to projects qualifying for NWP 26 that require neither Pre-Discharge Notification to the Corps or Section 401 water quality certification because they are less than 1 acre for project permitted in 1991 or less than 1/3 acre for projects in 1992 and 1993. These impacts have been recorded only for those developers who desire written confirmation that, because of project size, they are not required to apply for water quality certification.

permitted development resulted in the net loss of approximately 410 acres of wetlands per year.

The majority of uncompensated wetland impacts resulted from activities authorized under general permits. Nationwide permit 26 (headwater and isolated water discharges) was responsible for 62% of the total area permanently impacted and 90% of the total area impacted by general permits (Table 1). Yet, because these impacts occurred under a general permit and are assumed to result in only minimal adverse impacts, only 5.4% received compensation (as a result of conditions on the 401 certification).

On-site evaluation of 41 compensatory wetland projects throughout North Carolina revealed that only two projects were never implemented. Field delineation confirmed that most projects successfully created some amount of jurisdictional wetlands, under the 1987 Manual criteria (USACOE 1987). However, the majority failed to meet project goals for planned size and/or wetland community type, Based on qualitative evaluation, the substitute resources provided by compensatory mitigation were generally of mediocre quality, Contributing factors included: (1) regulatory preferences for on-site mitigation, which result in installation of compensatory wetlands in urbanized areas; (2) reliance on permittees to plan and implement mitigation projects; (3) regulatory staff limitations which prevent adequate review; and (4) ad hoc use of mitigation, which prevents consolidation of individually small compensatory projects into larger projects addressing regional resource needs.

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A STRATEGY FOR MONITORING THE SUCCESS OF WETLAND MITIGATION: PORTLAND DISTRICT'S EXPERIENCE

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This paper summarizes a review of actions taken by Portland District to evaluate the success of mitigation projects that required written monitoring reports, Two goals were established:

1. To acquire direct feedback on permit projects with mitigation that were nearing completion in order to assure timely approval, and/or corrective measures, and

2. To develop a uniformly applied way to evaluate the actual versus intended success of permittees and regulators in completing wetland mitigation projects as intended.

This effort was a means to focus internal action on ways to improve our permit description and follow-up evaluations of mitigation projects, Development and use of an evaluation form was an important activity that encouraged interactive involvement, resulting in more carefully crafted mitigation requirements that deliver the intended outcome objectives. Responses to the questions were shared with regulatory staff and in a series of meetings. other projects ensued that helped reduce the number of problems with mitigation projects. Mitigation projects that represent typical examples of successes or failures were presented in these meetings, with an emphasis on permits that lead to weak enforcement situations, The investigations and recommendations from others in the West Coast and other regions were shared to emphasize the timeliness of our effort.

Fifteen permits were found for projects that were over halfway complete by the Spring of 1993. Two years later several more permits had projects nearing completion, The permits found resulted from database searches and personal communication with project managers several months prior to the selection of projects qualifying for further review. These permits contain a total of 18 separate mitigation projects, Selection of the written report criteria eliminated permits that only required photo monitoring, Thus, the number evaluated in this paper is less than the initial estimate that 30 permits would be evaluated.

Overview

COE permits requiring mitigation for wetland fill became a major focus of interest in the early 1980's, but it wasn't until 1985 when interest culminated, resulting from negotiations with US Fish and Wildlife Service and Environmental Protection Agency, A November 8, 1985 COE Regulatory Guidance Letter became effective that implemented fish and wildlife mitigation into the regulatory program.

Approximately 4,500 Section 404 permits have been issued by Portland District between 1985 and 1992. Fifteen percent of those permits were individual permits. The remainder were Nationwide (NW) permits issued for areas that are above headwaters, Hundreds of NW permits were issued involving wetland fill, Occasionally mitigation was shown to be part of the permit, but seldom reported. Fifteen individual permits required written, analytical reports describing progress toward satisfaction of permit requirements. Such reports were required for this paper because they would provide direct evidence on how well the Corps communicated to achieve successful mitigation outcomes. Exhibit 1 contains the questions that were asked of evaluators and a summary of the

EXHIBIT 1

A SUMMARY OF EVALUATION FORMS COMPLETED FOR 18 MITIGATION PROJECTS

HYDROLOGY	% OF YES	RESPONSES
1. Is the report clear regarding water source(s) ?	94 %	(17)
2. Was data provided regarding satisfaction of water regime (hydroperiod, water depth, soil saturation) ?	75 %	(16)
3. Was there difficulty in predicting appropriate water regime ?	40 %	(15)
4. Were critical mitigation goals met with the apparent satisfaction of water regime requirements ?	71 %	(14)
5. Were hydrological adjustments done later during the monitoring period ?	53 %	(15)
6. Did adjustments satisfy permit requirements ? (Results of two actions are unconfirmed).	62 %	(8)
7. Did the permit provide for these adjustments ?	75 %	(16)
8. Did satisfaction of permit plans and requirements yield results that meet expectations ?	71 %	(14)

Responses to each question not always possible. Number in parenthesis indicates the number of responses.

VEGETATION	**% OF YES**	**RESPONSES**
1. Was the success closely linked to plantings ?	62 %	(16)
2. Did plantings meet mitigation objectives ?	57 %	(14)
3. Was success mostly dependant on natural revegetation ?	57 %	(14)
4. Was enforcement action needed to insure permit compliance ?	20 %	(15)
5. Were problems due to clarity of revegetation objectives ?	31 %	(16)
6. Did hydrology contribute to the failures ?	60 %	(15)

EVALUATION OF PERMIT CONDITIONS	**% OF YES**	**RESPONSES**
1. Were overall permit goals clear in the permit or the report ?	87 %	(16)
2. Did the permit conditions support mitigation goals ? (2 instances cannot be confirmed)	62 %	(16)
3. Were the mitigation acreage requirements satisfied ? (1 project was not confirmed)	87 %	(16)
4. Did the permit conditions prevent the Corps from requesting needed corrective action(s) ?	6 %	(16)
5. Did condition compliance yield the anticipated mitigation results ? (2 instances not be confirmed)	62 %	(16)
6. Permit mitigation requirement realistic and achievable ?	81 %	(16)

EXHIBIT 1
continued

CORPS/PERMITTEE PLANNING	% OF YES	RESPONSES
1. Was a natural wetland used as a model for the mitigation ?	62 %	(16)
2. Was another mitigation project used as a guide ?	50 %	(16)
3. Was there provision for or adjustments to the mitigation project ?	62 %	(16)
4. Was the complexity of the conditions appropriate for the project ? (1 project was unclear)	72 %	(17)
5. Agreement on the technical difficulties ?	80 %	(15)
6. Was a qualified agent used to field supervise ?	68 %	(16)
7. Does the site receive local protection ?	72 %	(18)

REPORT EVALUATION	% OF YES	RESPONSES
1. Reports submitted in time for effective review ?	60 %	(15)
2. Were reports logical and easy to review ?	81 %	(11)
3. Was data credibly gathered and analyzed ?	90 %	(11)
4. Corps response to report occur within 2 months ?	50 %	(16)
5. Does report provide a review regarding satisfaction of permit requirements ?	72 %	(11)
6. Does the report suggest corrective actions ?	81 %	(11)

Responses to each question not always possible. Number in parenthesis indicates the number of responses.

A SUMMARY OF FIELD VERIFICATION FOR 16 MITIGATION PROJECTS

1. The following are the items that were field evaluated

EVALUATION CATEGORY	NONE	MINOR	MAJOR
a. Water source(s). ----	68%	18%	14%
b. Water quantity/depth ---	50%	37%	13%
c. Physical features ---- (shape, slopes, depth)	56%	37%	7%
d. Human impacts ------- (trash, vandalism).	66%	27%	27%
e. Planting success -----	53%	33%	14%
f. Unwanted vegetation ---	50%	37%	13%
g. Chronic wildlife damage	60%	33%	7%
h. Soil development ------	70%	20%	10%
i. Acreage of new wetland or boundary issues -----	75%	25%	0%
j. Wetland function issues -	75%	19%	6%

(Data was not reported for every category and two projects were not visited)

2. Does reporting corroborate with field verification ? ---- Y=66% N=0% Unknown=33%

3. Will the Corps or the consultant be required to make further measurement to verify success. ---- Yes=50% No=50%

responses.

Conclusion

The matter of compliance follow-up is important, and the responsibility for insuring that reports are evaluated is a high priority, It demonstrates a commitment to our regulated customers in Oregon and Washington, When reports are received, responsiveness and quality review are critical, The mitigation evaluation checklist developed for this paper will receive additional, internal review, The checklist also can be used by A/E contractors for review of permit mitigation projects, The next goal is to achieve consistent internal support and to promote improved mitigation description in COE permits.

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RESULTS OF WETLANDS MITIGATION ASSOCIATED WITH HIGHWAY PROJECTS

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Seventeen wetland compensatory mitigation projects established in 14 states under Section 404 requirements were analyzed by qualitative descriptions of procedures and site

conditions, and comparisons with reference wetlands using Wetland Evaluation Technique (WET) (Adamus et al, 1987) and the Hollands-Magee (H-M) (Hollands and Magee 1986) functional assessment procedures to evaluate their success in replacing or replicating wetland functions (FHWA 1991). Restoration, creation, and enhancement projects were evaluated.

The mitigation projects evaluated were completed between dates 1981 and 1988. The average site age was 3. 6 years. A total of 444 acres were impacted. The median impacted area was approximately 8 acres; the maximum, 273 acres; the minimum, 0 acres. Impacts by wetlands type were palustrine forested, 275 acres; palustrine shrub/scrub, 66 acres; palustrine emergent, 70 acres. Approximately 250 acres were developed as compensatory mitigation; of this an estimated 85 acres of existing wetlands were modified. Creation of new wetland from upland accounted for 54%; restoration, 14%; enhancement of existing wetlands (conversion of one wetland type to another to enhance specific functions, such as habitat), 34%.

All mitigation projects studied resulted in recognizable wetlands. Compensatory mitigation goals were characterized by managers as partially met at 14 sites, and as being completely met at three sites. Seven projects showed a net loss of area, five, a net gain, and four had gains balancing losses (one project was an advance bank and was not included). The majority of projects evaluated were not functionally equivalent to wetlands impacted. On most projects, area-for-area replacement and functional equivalency were not identified objectives of the permit conditions. Mitigation objectives were commonly identified on the basis of a perceived need, or site potential; habitat was the most commonly identified functional objective, followed by hydrologic functions. Ownership and availability appeared to be a major consideration in the selection of mitigation sites and objectives. Habitat mitigation objectives were generally based on: 1) a shortage or need of habitat for a particular species or guild (shorebirds, waterfowl); or 2) site potential.

On four projects existing wetlands were converted from one wetland type to another, for instance from palustrine emergent, palustrine shrub/scrub, or palustrine forested to open water, submergent wetlands. These projects were considered enhancement or creation projects. Eight projects used old or newly developed material sources (borrow pits) as all or part of the mitigation site.

Comparisons between functional indicators were made between all 17 mitigation sites and reference wetlands using the H-M and WET methods. For WET a comparison was considered negative if the functional index went High>Moderate>Low; positive if the functional index went Low>Moderate>High. In 19 WET comparisons, habitat-related functions (Wildlife Diversity for Breeding,

Migration, or Wintering) resulted in 27 negatives (47%), 4 positives (7%), and 26 no change (46%), out of a possible 57. The Production Export function was not included. Water quality-related functions resulted in 12 negatives (21%), 9 positives (16%) and 36 (36%) no change out of 57 comparisons made. Hydrology-related functions (Flood Flow Alteration) resulted in 4 negatives, 1 positive, and 14 no change.

Comparisons of the Biological Function of H-M resulted in 10 negatives(0.55), 6 positives (0.33), and 2 no change out of a possible 18. Water quality-related functions resulted in 12 negatives(0.66), 4 positives (0.22), 2 no change, of a possible 18. Hydrology-related functions resulted in 23 negatives(0.64), 10 positives (0.27), 3 no change out of a possible 36. Comparisons of overall site conditions made using both methods showed relatively good agreement (13 out of 18 agreed, 5 disagreed).

Apparent reasons that projects did not meet functional criteria or resulted in a loss of functional capacity or condition include: 1) changes in other environmental management activities or conditions which affected the mitigation project, 2) failure to carry out the mitigation plans, 3) projects inadequately or improperly designed to meet objectives, 4) objectives not adequately defined, 5) mitigation plans and objectives not consistent with site potential, and 6) insufficient time for mitigation projects to develop mature site characteristics.

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MONITORING OF A WETLAND MITIGATION SITE IN THE SACRAMENTO RIVER DELTA, CALIFORNIA

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Wetland evolution and mitigation success of a tidally influenced freshwater wetland has been evaluated since 1992; an adjacent wetland reference site is also being evaluated. The overall goal is to describe the long-term spatial pattern of marsh evolution. Sediment accretion patterns and change of bathymetry and vegetation composition over time may allow prediction of long-term restoration trends. Compiling a long- term data base of sediment accretion rates, revegetation, soil and water chemistry, and other marsh building processes will contribute to prioritization of potential mitigation/restoration sites in the Sacramento-San Joaquin Delta. Trends in vegetation variation over time have been evaluated using Canonical Correspondence Analysis, which may lead to explanations of vegetation gradients in terms of environmental factors (soil chemistry and elevation).

RATING MITIGATION SUCCESS: A MODEL WHICH RATES SITE SPECIFIC WOODY VEGETATION ASSOCIATIONS PLANTED TO MEET GOALS OUTLINED IN A HEP ANALYSIS

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Introduction

On the Ice Harbor/Lower Monumental Project, in Southeastern Washington, approximately 1443.4 hectares have been designated as Habitat Management Units (HMUS) under the Lower Snake River Fish and Wildlife Compensation Plan. The majority of terrestrial wildlife habitat development has been performed on Big Flat, Lost Island, Hollebeke, Skookum, and 55 Mile HMUS. Approximately 249.1 hectares are currently under irrigation within these units. Of these irrigated lands, about 123.7 hectares are designated as shrub and tree plantings. This investigation was conducted in the 70 designated shrub and tree areas found within the five HMUS.

Methods

Each of the mapped shrub and tree areas were surveyed by ocular estimation to determine species composition and relative species dominance. Each shrub and tree species was given cover percentages based on the total shrub and tree cover. An ocular estimation of shrub or tree species heights were also recorded for specimens over 3.8 meters in height. Field forms were compiled using Dbase III+ software on a personal computer.

The parameters for this model are based on data collected during this survey and information available from Christianson and Ross (1991) and Asherin and Claar (1976). Other parameters were derived from HEP models for Hairy Woodpecker, Mule Deer, osprey and Blackcapped Chickadee.

The first parameter used on all shrub and tree areas was continuity of the stand. A stand with over half the cover total in one clump was rated as closed. A stand with individual clumps making up one-quarter to one-half of the total area was rated as open. A stand with each clump making up less than one-quarter of the total area was rated as sparse.

A second parameter applied to all areas was distance to water and the type of water. If a stand was within 30.8 meters of the river shoreline, then it was given a code of WS. If a stand was within 30.8 meters of a pond, then it was given a code of WP. If a stand was within 30.8 meters of guzzler, then it was given a code of WG.

For palustrine/riparian forest a point system was developed based on the available variables derived from this survey. The categories used were hectares of canopy greater than 6.1 and 9.2 meters in height, hectares of canopy greater than 6.1 and 9.2 meters in height which is softwood (*Populus*, *Ulmus*, *Salix*), and hectares of canopy over 6.1 and 9.2 meters capable of supporting perches for large birds (i.e, any tree over 6.1 and 9.2 meters which is not *Elaeagnus angustifolia*).

The palustrine/riparian forest parameters were set to give the highest rating to a stand which best mimics a naturally occurring riparian forest for this climatic region. This would be a softwood forest with a canopy greater than 9,2 meters high, within 30.8 meters of the river, and over 2.1 hectares in size,

Parameters for mesic shrubland were based on percent of browse shrubs less than 3.8 meters in height in relation to the total hectares of shrubs less than 3.8 meters in height. Browse shrubs were all trees and shrubs except *Elaeagnus angustifolia*, *Caragana arborescens*, *Crataegus* spp., and *Rubus* spp.

The mesic shrubland parameters were set so the highest rating was given to an area of shrubs and trees less than 3.8 meters in height, over 0.82 hectares in size, within 30.8 meters of water, and composed of browsable trees and shrubs making up at least 50% of the total canopy. The scoring system for palustrine/riparian forest is outlined in Table 1. The scoring system for mesic shrubland is outlined in Table 2.

Results and Discussion

Approximately one-sixth of all hectares in the 70 shrub and

TABLE 1
Palustrine/Riparian Forest Model

Parameter 1. Hectares of trees ≥ 6.1 meters in height-
- a) > 2.1 hectares- 6 points; If ≥ 9.2m in height, 8 points;
- b) > 0.82 hectares- 4 points; If ≥ 9.2m in height 5 points;
- c) > 0.21 hectare- 2 points; If ≥ 9.2m in height, 3 points;
- d) ≤ 0.21 hectare- 0 points; If ≥ 9.2m in height, 1 point.

Parameter 2. Hectares of trees ≥ 6.1 meters in height and softwood-
- a) > 2.1 hectares- 6 points; If ≥ 9.2m in height, 10 points;
- b) > 0.82 hectares- 4 points; If ≥ 9.2m in height, 8 points;
- c) > 0.21 hectare- 2 points; If ≥ 9.2m in height, 4 points;
- d) ≤ 0.21 hectare- 0 points; If ≥ 9.2m in height, 2 points.

Parameter 3. Hectares of tress ≥ 6.1 meters in height and perch trees-
- a) > 2.1 hectares- 6 points; If ≥ 9.2m in height, 10 points;
- b) > 0.82 hectares- 4 points; If ≥ 9.2m in height, 8 points;
- c) > 0.21 hectare- 2 points; If ≥ 9.2m in height, 4 points;
- d) ≤ 0.21 hectare- 0 points; If ≥ 9.2m in height, 2 points.

If the stand was rated as open, 2 points were deducted from the total score.
If the stand was rated as sparse, 4 points were deducted from the total score.
If the stand was <30.8m from a guzzler or pond, 2 points were added to the total score.
If the stand was <30.8m from the shoreline of the river, 4 points were added to the total score.

The final scores were categorized as follows: Excellent (E) ≥25; Good (G) ≥16 and <25; Fair (F) ≥9 and <16; Poor (P) ≥3 and <9.

TABLE 2
Mesic Shrubland Model

Parameter 1. Hectares of shrubs and trees <3.8 meters in height-
- a) > 0.82 hectares- 6 points, If browse shrubs and trees were 50% of total cover- add 6 points;
- b) > 1 hectare- 4 points, If browse shrubs and trees were 50% of total cover- add 4 points;
- c) > 0.1 hectare- 2 points, If browse shrubs and trees were 50% of total cover- add 2 points.

If the stand was rated as open, 2 points were subtracted from the growth form score.
If the stand was rated as sparse, 4 points were subtracted from the growth form score.
If the stand was <30.8m from a guzzler, pond, or river shore, 2 points were added to the total score.

The final scores for Mesic Shrubland were categorized as follows:
Excellent (E) 12; Good (G) ≥8 and <12; Fair (F) ≥4 and <8; Poor (P) <4.

tree areas were classified as fair or better for palustrine/riparian forest. About two-thirds of the total shrub and tree area classified out as fair or better for mesic shrubland.

When these results were compared with what is actually found on the ground the model provided a fairly accurate assessment of shrub and tree developments. These developments are only 12-15 years old at the most. There is an obvious lack of softwood trees planted on these habitat development areas. The model, with additional refinements, is quick and easy way to obtain some type of quantifiable assessment of mitigation plantings which can be used to plan for future habitat developments.

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SESSION RE9

RESTORATION, PROTECTION, AND CREATION: CENTRAL US WETLAND RESTORATION AND CREATION PROJECTS

Michael C. Gilbert, Chair

PLANNING FOR ENVIRONMENTAL RESTORATION AT GREENFIELD BAYOU, INDIANA

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The US Army Corps of Engineers, Louisville District, is preparing a feasibility report on a project in Vigo County, Indiana. This proposal includes agricultural flood protection and environmental restoration as primary purposes for a major river bottom area along the Wabash River. These two elements are being designed to compliment the other feature; an accomplishment that would not have been possible until recently.

The Greenfield Bayou project was originally conceived as a pure agricultural flood protection levee that would have significantly modified a major block of bottomland forest by isolating that resource from periodic flooding. Current project proposals include protecting this forest block from being cut off from the river, increasing the size and eliminating openings in the forest block with planting programs, managing for wildlife, waterfowl, and shorebirds, providing opportunities for active and passive recreation, and creating environmental education areas. Considered environmental restoration alternatives now include 4000 to 5000 acres.

This project is a partnership between US Army Corps of Engineers, US Fish and Wildlife Service, Indiana Department of Natural Resources, Vigo County, and Indiana Michigan Power Company. Ducks Unlimited is also considering becoming a participant.

EVALUATION OF WEAVER BOTTOMS RESTORATION PROJECT ON THE UPPER MISSISSIPPI RIVER

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Gradual loss in the past 25 years of submergent and emergent herbaceous vegetation in backwater wetlands of the Upper Mississippi River that were flooded 60 years ago has led to degradation of important staging areas for migratory waterfowl. In 1987, dredged material was used to close side channels and construct islands in Weaver Bottoms, a 5000-acre degrading wetland in the Upper Mississippi River National Fish and Wildlife Refuge Complex near Winona, MN, to reduce water turbidity and scouring by strong river currents.

Primary effects of the rehabilitation project were to reduce water current speed within Weaver Bottoms and to increase retention time of water and its sediment load. Most water quality parameters remained closely correlated with conditions in the Mississippi River, but became more influenced by the Whitewater River, a turbid tributary which empties directly into Weaver Bottoms. Turbidity was not decreased by the project, and wetland and aquatic vegetation and waterfowl use continue to decline. While the project has had little effect on vegetation, positive or negative, the cause of the continued over-all decline of wetland and aquatic vegetation in the Upper Mississippi River remains unclear.

CREATING WETLANDS TO ENHANCE A GOLF COURSE: SOWING SEEDS OF SUCCESS

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A Challenge

The Park District of New Lenox, Illinois recently purchased 230 acres of land for a golf course. The site's gently rolling terrain and meandering creek set against a backdrop of wooded slopes appeared ideal. However, surprises were in store for them. Challenges they were soon to face included:

- Significant archaeological finds (a burial and village site),

- A creek considered by agencies to be high quality and sensitive,

- Over 60% of the site in floodplain, with a creek that floods its banks frequently,

- Groundwater within 2-3 feet of the surface in many areas, and

- Several existing jurisdictional wetlands.

These challenges were ultimately overcome through creative design solutions, including the creation of 5+ acres of wetlands around a series of lakes designed for flood conveyance and storage (Figure 1).

Opportunities and Constraints

Wetland Delineations - atypical situation. Field studies identified several acres of riparian forest wetlands, and about 3 acres of scrub/shrub wetlands. The scrub/shrub communities were quite degraded due to many years of farming on adjacent uplands. The "atypical situation" arose from this farming activity. Nearly 80% of the site was cleared of vegetation and plowed for row-crop production. Soils in the lower lying farmed areas were classified as "hydric". Based on the level of existing and historic disturbance, Natural Resources Conservation Service personnel concluded that these farmed areas were considered "prior converted cropland" and not "farmed wetlands".

Archeology and Other Constraints. Archaeological investigations identified several "significant" features, the most notable being a burial pit and a village site. Extensive agency consultation resulted in 19 acres being defined culturally as a Nationally Significant Site.

The preponderance of floodplain (over 60% of the site within the 100-yr floodplain) was another significant constraint. Consequently, hydrologic studies were required to ensure that the development would adequately convey floodwaters.

The Water Dilemma A key program requirement was the need to develop a dependable irrigation water supply , as the course would require about 1500 gpm over an eight hour period each day. Due to the limited knowledge and general unpredictability of groundwater, the Project Team initially proposed to utilize both groundwater and surface water sources. A small (2 feet) weir was proposed to divert creek water into the proposed ponds. While the idea was logical, and resource impacts minimal, State Conservation and Regional Fish and Wildlife Agencies would not agree to any development on the creek. After several discussions with the Agencies, plans for a weir and diversion were discarded.

Table 1. Summary of Wetland Acreage

Cover Type	Existing	Impacted	New
Forested	28.2	0.2	0
Scrub/Shrub	2.7	0.93	0.46
Emergent/Wet Prairie	0	0	3.74
Open Water/ Submergent	0*	0	10.0+
Totals	30.9	1.13	14.2

* excludes creek

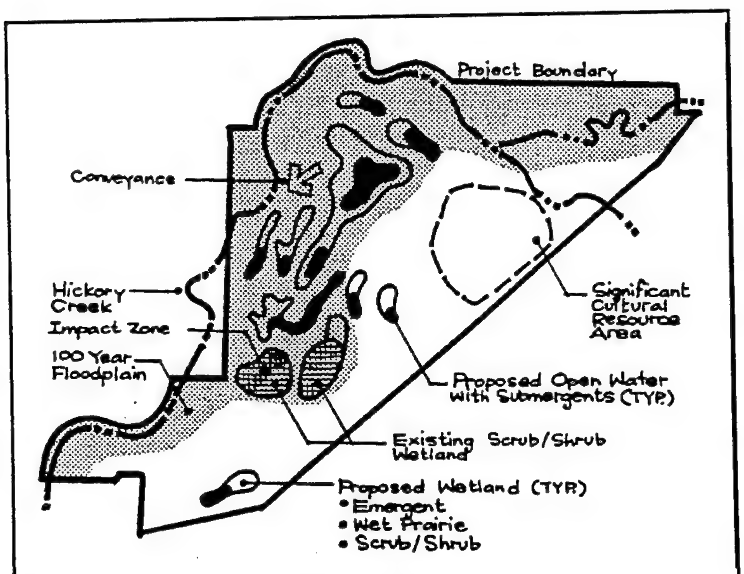

Figure 1 Conceptual Wetland Plan

Wetland Mitigation

Proposed ponds and the high groundwater table provided the opportunity to create number of wetland communities (Table 1). Slopes adjacent to many of the ponds will be graded at 30:1 or flatter to provide emergent and sedge meadow zones. Hydric soil excavated from on-site will be used as a planting medium. A sedge meadow mix consisting of sedges, rushes, and forbs will be seeded just above (0 to 1 foot) the waterline. Emergent plugs will be planted in shallow water zones (0 to -1 foot), and floating submergents will be planted in pond areas up to 3 feet deep. A central pond, which is the main irrigation source has been designed to be over 16 feet deep and nearly seven surface-acres in size. The pond's large volume will help minimize drawdown and associated wetland impacts. Positive flow will be achieved by hydrologically connecting project ponds and setting the creek outlet slightly below the level of the ponds. The proposed wetland mitigation will provide nearly a 3.6:1 wetland mitigation- to-impacted wetland ratio. Existing and proposed wetland areas will be surrounded by buffer zones of native grasses and forbes.

Conclusion

Final grading is scheduled for completion in the early spring of 1995. Wetlands will be constructed in late spring or early summer. Wetland planting may be delayed until the fall in order to observe groundwater conditions through the drier summer months.

Groundwater the key. The success of these proposed wetlands rests with the reliability of the groundwater. Established grades and elevations are a "best guess" at providing the hydrological functions necessary to sustain diverse wetland communities.

The idea that golf courses have to be completely manicured and chemically dependent to be successful is changing. Thanks to the environmental awareness of its client, the New Lenox Community Golf Course goes beyond fulfilling a permit obligation to show that wetland values and functions can be successfully integrated with the creation of a challenging golf experience.

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AVIAN UTILIZATION OF RESTORED AND CREATED WETLANDS IN INDIANA

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We have been examining the abilities of models to predict avian utilization of restored or created wetlands based on wetland characteristics. Stepwise forward multiple regression models show that in northern Indiana breeding bird species richness is correlated positively with restored wetland size (area) and aquatic plant biomass, and species diversity is correlated positively with wetland area and negatively with inter-wetland distance. Waterfowl nesting pairs are correlated with wetland area and amount of adjacent cover. There is no significant difference between species diversity at restored and natural wetlands. In contrast, created wetlands in previously strip-mined areas in southern Indiana with similar habitat characteristics do not necessarily show similarities in bird assemblages. Bird species richness does show a positive correlation with submergent vegetation species richness, but also a negative correlation with emergent vegetation species richness. There is no correlation between bird species richness or diversity and wetland size or age. Discussion will include pitfalls and shortcomings of using bird communities to assess the ecological dynamics of restored wetlands and suggestions for implementation of such a program.

WETLAND CONSTRUCTION AND ENHANCEMENT AT THE GERALD GENTLEMAN STATION RAIL SPUR MITIGATION SITE, PROGRESS OF THE FIRST YEAR

Michael P. Gutzmer and David P. Overhue

Introduction

Gerald Gentleman Station (GGS),located in southwestern Nebraska near Sutherland, is the newest and largest electric-generating facility in the Nebraska Public Power District (NPPD) system. The District recently constructed and completed a 9.2 mile long rail spur between the Station and the Union Pacific Railroad to create competition in the coal-hauling market. Construction of the spur was completed on August 15, 1994.

A multi-objective criteria analysis was used to identify a rail spur route with the optimal combination of low environmental impact, favorable engineering characteristics and economic feasibility. Environmental and social considerations in the 86-square mile study area included the South Platte River; two high quality stream segments; riparian, slough and isolated wetlands; Sutherland Reservoir and adjacent recreation areas; water supply and irrigation canals; center-pivot and gravity-flow irrigation systems; the Oregon Trail; O'Fallon's Bluff National Register site; Interstate Highway 80; U.S. Highway 30; the towns of Sutherland and Hershey; rural farmsteads; and agricultural lands. Ultimately, the analysis was effective in distinguishing the least damaging, practicable alternative base on cost, logistics, existing technology and environmental impacts.

Methods

Alternative corridors for route selection were developed based on preliminary routing criteria defined by undesirable environmental and socioeconomic impacts and engineering design constraints. Environmental/wetland impacts were weighted 2:1 over socioeconomic impacts and engineering constraints. The criteria included avoidance or minimization of impacts to environmentally sensitive areas, endangered species, wetlands, waterways, historic places, cemeteries, farmhouses, churches, schools, existing population centers, public facilities, state and county lands, and center-pivot irrigation systems.

Results and Discussion

Based on jurisdictional delineations conducted following the 1990 Unified Federal Method, the GGS rail spur project impacted 1.95 acres of wetlands. These delineations were field verified by an interagency site visit on 2 July 1991 which included representatives of the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, USDA. Soil Conservation Service, Nebraska Department of Environmental Quality. We proposed in our mitigation plan to compensate for wetland losses at a ratio of 2:1 replacement, as well as habitat enhancements on adjacent wetlands located on a wetland complex (District property) at Sutherland Reservoir.

The 1.95 acres of permanent wetland impacts consist of the loss of 1.54 acres of isolated wetlands, 0.20 acres of slough wetlands and 0.21 acres of riverine wetlands (see below). An additional 2.80 acres of riverine wetlands were disturbed temporarily from June 1992 through summer 1993 for construction of the South Platte River bridges.

The wetland mitigation at the Sutherland Reservoir site involved excavation of approximately four acres of land adjacent to existing wetlands. The construction attempts to create

WETLAND LOSSES IN THE RAIL SPUR RIGHT-OF-WAY

Wetland	NWI Classification[1]	Acres
Drainage to Bull Ditch Section 22, T14N, R34W	PEMC	0.24
Return irrigation-maintained farmed wetland Section 27, T14N, R34W	$PEMC_x$	0.09
North channel South Platte River Section 27, T14N, R34W	R2USA	0.20
South channel South Platte River Sections 34 & 35, T14N, R34W	R2USA	0.01
Drain Number 5 Section 2, T13N, R34W	$R4SBF_x$	0.09
Applegate Drain Section 2, T13N, R34W	$R4SBF_x$	0.11
0.54-acre farmed wetland Section 11, T13N, R34W	not shown	0.34
6.15-acre farmed wetland Section 24, T13N, R34W	PEMA	0.87
SUBTOTAL Isolated Wetlands	(PEM)	1.54
SUBTOTAL Slough Wetlands	(R2SB)	0.20
SUBTOTAL Riverine Wetlands	(R4US)	0.21
TOTAL WETLAND LOSSES		1.95

[1]Based on the Draft National Wetland Inventory maps, USFWS, 1991

approximately 0.4 acres of semipermanently, 0.7 acres of seasonally, and 2.8 acres of temporarily flooded wetlands. This was to compensate for wetland losses at a ratio of 2:1 replacement. Available information concerning topography, water levels (surveyed elevations of existing open water at time of site visit, September 1991), and other characteristics of the existing wetlands was used to formulate guidelines for areal extent and excavation depths that would support the constructed wetlands. Using these guidelines and information guidelines, two distinct areas located adjacent to the northwest corner and southern tip of the existing wetlands were identified as wetland mitigation sites. The total volume of soil to be removed from these sites was estimated at approximately 36,000 cubic yards.

Wetlands construction involved a field survey that was conducted to identify (flag) the extent of the existing wetlands and to stake cut areas for excavation purposes. The survey also identified haul road routes. Care was taken not to intrude in any existing wetlands with equipment or stockpiles.

Construction of the wetlands was initiated during winter 93/94. Construction was performed using NPPD equipment and

personnel. Equipment required for construction included a scraper, front-end loader, and other necessary miscellaneous equipment. In January 1994 Russian olives, eastern red cedars and other shrub vegetation located in the adjacent existing wetland vegetation was piled and burned to enhance the area as waterfowl habitat.

Earthwork for the site commenced in late January 1994 on the south side. Approximately 6 inches of topsoil (native seed reservoir) was removed from the site and temporarily stockpiled for later topsoil treatment of the spoil material. Spoil material from the excavation was placed (over approximately 11 acres) along the face of the dam running along the east side of the existing wetlands area. Stockpiled topsoil was placed on the spoil to final grade to help minimize run-off into the constructed wetland. Excavation on the south side was completed in mid-April 1994. The area was then seeded with a general floodplain mix.

Approximately two acres remaining to be excavated on the north side of the wetland complex was completed in mid-November 1994. The exposed spoil areas as well as new wetland areas were prime areas for thistle encroachment and the entire wetland complex was treated with a 3 percent Rodeo solution and surfactant on June 26 and 30. At that time a federally- threatened species, a piping plover, was observed sitting on a nest with three chicks on the south excavation site. A three- strand barbed wire fence, including access gates, was placed to enclose the existing and mitigated wetlands and adjacent uplands (64 acres).

Plans for 1995 include a partial burn, and reseeding all excavated areas along with an existing (and new) vegetation survey. Continued monitoring of the site will also incorporate an active noxious weed, primarily canadian thistle, management program on the wetland site.

SESSION RE10

RESTORATION, PROTECTION, AND CREATION: GENERAL WETLAND CREATION AND RESTORATION

Suzanne Hawes, Chair

BENEFICIAL USE OF DREDGED MATERIAL FROM THE DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT TO CREATE, RESTORE, AND PROTECT WETLANDS IN THE DELAWARE BAY

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The Delaware River Comprehensive Navigation Study Main Channel Deepening Interim Feasibility Report and Environmental Impact Statement recommended from its feasibility study modification of the existing federal navigation channel from 40 feet at mean low water (MLW) to 45 feet. The proposed project, authorized as part of the Water Resources Development Act of 1992, provides for a full width channel that would follow the existing channel alignment from the Delaware Bay to the Philadelphia/Camden waterfront, a distance of approximately 102.5 miles, appropriate bend widening, and a 2-space anchorage at Marcus Hook. Approximately 50 million cubic yards (MCY) of dredged material will be removed for initial construction over a 5-yr period. Dredged material from the upper river will be confined. Material excavated from the lower river (Delaware Bay) is primarily sand, and will be used for several beneficial purposes, including wetland restoration and protection, underwater sand stockpiling for future shore protection, and possible beach nourishment.

A critical component of this feasibility study is the design of the beneficial use projects at Kelly Island, DE, and Egg Island Point, NJ, wetland sites, and sand stockpile and beach nourishment sites in Delaware. The US Army Engineer District, Philadelphia, and the US Army Engineer Waterways Experiment Station have teamed to develop, design, and implement these beneficial uses.

Egg Island Point

Egg Island Point, NJ, a prime fish and wildlife area, has undergone extensive land and marsh losses due to erosion for many years. Emphasis will be on shore protection and habitat diversity to accommodate a variety of species. An small unconfined sand island would be constructed at the eroding tip of Egg Island Point over a remnant peat bank to approximately +15 ft MLW, with a slide

slope of 1:10 to 1:15. This sand area targets use by spawning horseshoe crabs, nesting seabirds, and migrating shorebirds.

Geotextile tubes filled with sand dredged from the project will be placed near the shore for up to two miles on the southeast side of Egg Island Point. In addition, geotextile tubes and/or an unconfined sand beach will be placed for up to two miles on the northwest side of Egg Island Point. Both of these soft structure formations will be used in an effort to hold Egg Island Point to its present size and configuration. Underlying the geotextile tubes will be a sand foundation covered with a geotextile anchored scour blanket built to 0 ft MLW; this foundation will raise the top elevation of the tubes to approximately +5 MLW, near the high tide level for the site. Additional sand will be placed behind the tubes to raise the eroded elevation to a low marsh level.

Kelly Island

Kelly Island, DE, adjacent to the Mahon River and part of the Bombay Hook National Wildlife Refuge, is also eroding severely. In addition to its fish and wildlife value, it also provides some protection for a fishing port and off-loading terminals for Dover Air Force Bay. Emphasis will be on confinement of the 0.9 MCY in the project that is fine-grained, as well as using sand for shore protection and wetland restoration.

Geotextile tubes will be filled with sand dredged from the project near the shore for approximately two miles extending northward from the southern, eroded tip of Kelly Island. A sand foundation will also underlie the tubes, to raise the final elevation to +6 ft MLW, near the high tide level for this site. To ensure confinement of the fine-grained material until it consolidates and marsh is established, an additional tube will be placed on top of the primary tube to raise the elevation to at least +11 ft MLW.

Fine grained material will be placed behind the completed tube structure to a low marsh elevation, and an intertidal connection will be established on the wetland's most protected side. Exact dimensions and elevations will be determined by a detailed engineering analysis. Parts of the wetland will be planted with Spartina alterniflora, with emphasis on areas most vulnerable to interior site erosion.

Beach Nourishment and Sand Berms

Areas of beach nourishment in Delaware will be selected in coordination with the Delaware Department of Natural Resources and Environmental Control, and with the US Fish and Wildlife Service to select areas most beneficial to spawning horseshoe crabs. Delaware Bay has the largest population of this species in the world, and the crabs spawn heavily on the remaining sand beaches and berms in

the Bay. Currently, beaches between the Mispillion River and Roosevelt Inlet, and at Port Mahon, are being evaluated.

Approximately 5.8 MCY of the sand material will be placed at a location in the lower Delaware Bay near Lewes, DE, and cover approximately 500-700 acres about one mile from shore. This would decrease bottom depths approximately 7 ft, to a bottom depth of -5 ft MLW. In addition, an underwater sand berm is being considered 0.5 miles offshore at some location between Kelly Island and Murderkill River. Both of these areas will provide a future sand source for the State of Delaware as it addresses continued erosion along the Delaware side of the Bay.

RESTORATION OF SAGINAW BAY COASTAL WETLANDS IN MICHIGAN

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Wetland conversion in the United States resulted in loss of more than 50% of all wetlands with over 11 million acres of wetlands converted by the 1970's (Dahl 1990). Michigan has also lost 50% of its wetlands to development. Efforts to create new wetlands to offset some of these losses have rarely been successful due to insufficient knowledge about wetland structure and function. As experience builds, it has become apparent that efforts to restore areas that were originally wetlands are more likely to succeed than are efforts to create wetlands in upland areas (Kusler and Kentula, 1989).

The Michigan Department of Natural Resources (MDNR) plans to restore several thousand ha of former coastal wetland with emphasis on the wet meadow zones in the former lakeplain prairie on land adjacent to Saginaw Bay within the 585 ft contour to lake level (currently at 579.2 ft) zone (Fig. 1). The land to be restored is on drained, hydric soils that must be actively pumped to keep crops, primarily potatoes, sugar beets, beans, and corn, from flooding.

Wetland restoration techniques are site dependent, and no general predictive model exists that will enable a design of a successful restoration effort. Instead, one must first develop an

understanding of the factors that lead to formation of specific wetlands. A regional approach must be taken to include hydrology and soils data for existing wetlands; the impact of soils and water level on development of plant communities; the impact of plant composition and structure on animal uses of wetlands; and the impact of watershed dynamics on water quality and quantity. Site evaluation should include a baseline vegetation survey, water level data including pertinent elevational data, wildlife utilization observations, and general fish and macroinvertebrate data (Erwin, 1990). We are currently collecting these baseline data for Saginaw Bay wetlands.

Vegetative structure of presettlement wetlands ranged from Great Lakes Marsh/Emergent Marsh to Ash, Elm, Maple, and Birch swamps; from Lakeplain Prairie to Shrub Swamp and Bog according to maps of original wetlands prepared by MDNR Natural Features Inventory from surveyors records (Fig. 2). The majority of wetland communities were inland sites dominated by such vegetation as wild rice (Zizania), sedge (Cyperaceae), reeds (Phragmites), sand cherry (Prunus pumila), prairie dock (Silphium terebinthinaceum), northern white cedar (Thuja occidentalis), and tamarack (Larix laticina). Cyclic variations in vegetative composition were not uncommon according to the original land surveys and were largely attributed to Bay water level fluctuations. Most of lakeplain prairie and swamps were lost due to agricultural drainage in the early 1900's. Approximately 70% of the original inland wetlands are now cropland and less than 1% of the lakeplain prairie wetlands remain. Wetland communities that remain are found at sites in shallow areas along the shore that are subject to wave action and ice scour. These sites are dominated by a few species such as cattail (Typha) and bulrush (Scirpus). Variation between such sites is small and diversity is limited to only hearty species that tolerate disturbances such as wave action and extreme water level fluctuations. Avian productivity and muskrat use of these marshes represents a high risk venture due to large shifts in water level related to seiches.

In 1993 and 1994, we developed an initial landscape perspective of the extent of wetlands in the area, and collected data on biota to assess function and value to wildlife in selected, representative wetlands on 7 sites (Fig. 1). Although these data suggest that there is a rich flora and fauna in the existing wetlands that can serve as sources of seeds and immigrants to nearby restored areas, seed bank studies suggest that very few viable seeds of wetland plants remain in agricultural soils. Very little of the original lakeplain prairie vegetation exists and may be the most difficult to restore because of lack of seed sources and a tendency for shallow, disturbed environments to be invaded by purple loosestrife.

Initial data analyses from a 10 year old successional site suggest that wetland flora and fauna will be slow if seeding and/or

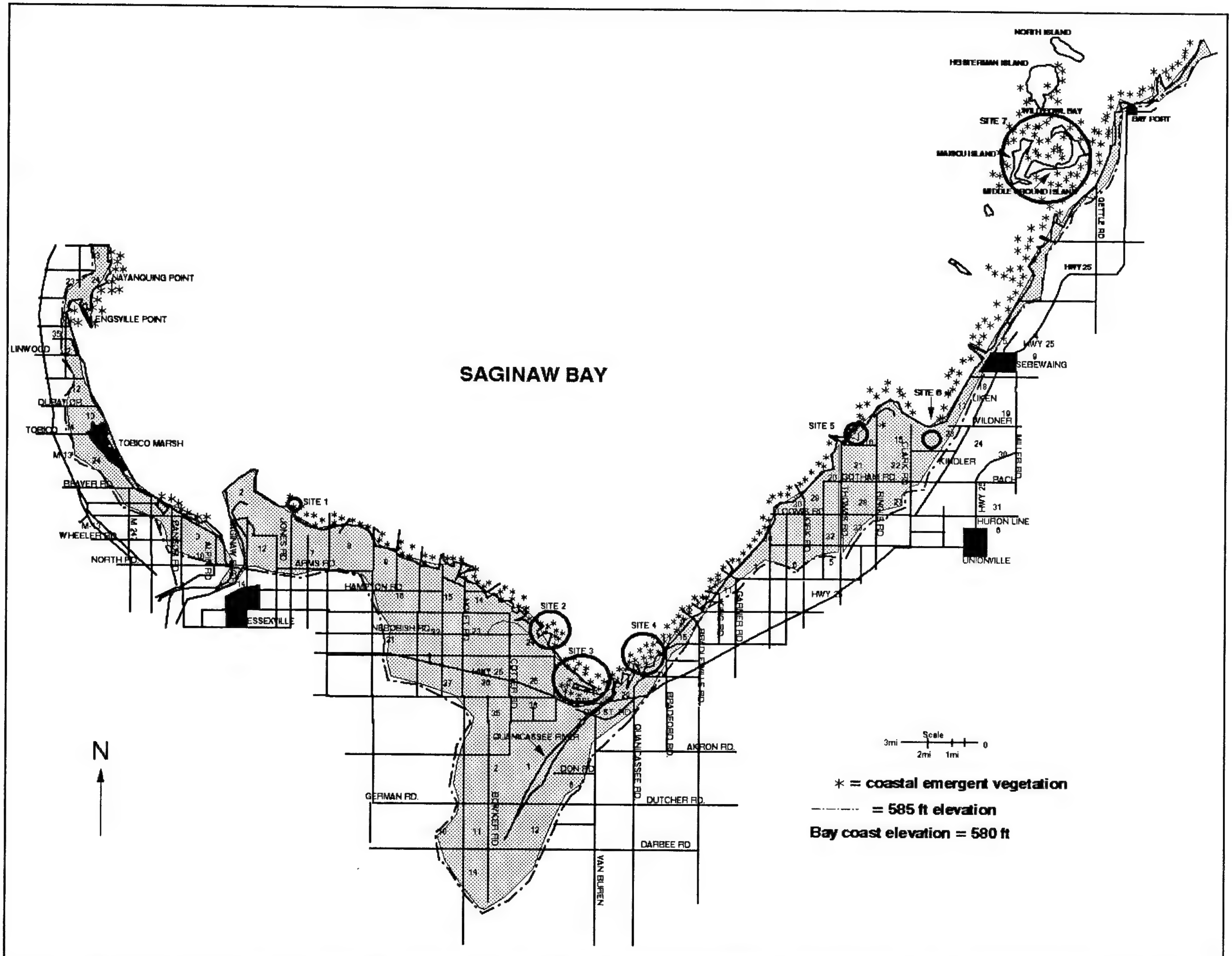

Figure 1. Saginaw Bay wetlands restoration sites. Bay, Tuscola, and Huron Counties. Shaded area represents elevations within 585 ft contour line (approx. 13,823 ha).

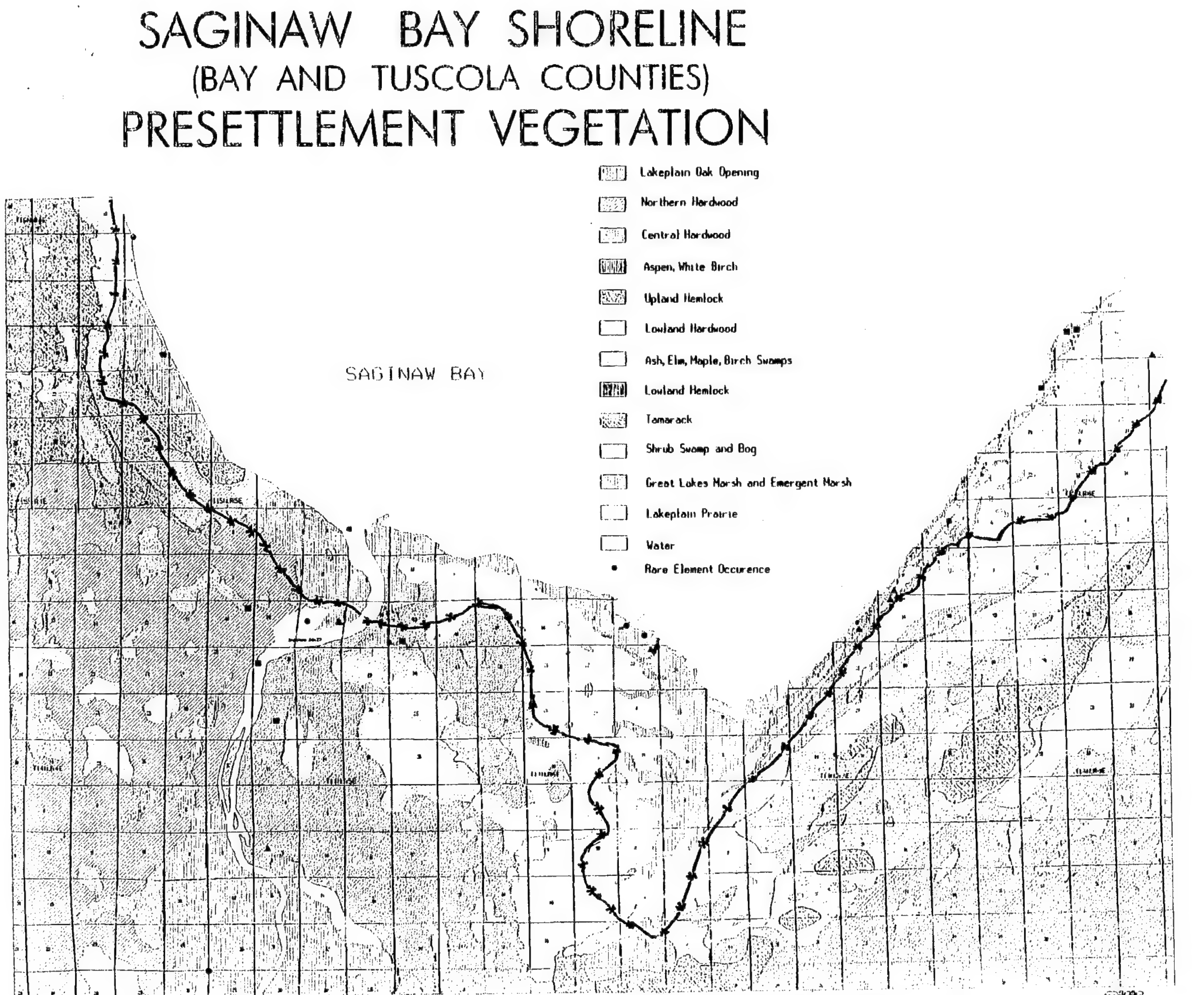

Figure 2. Saginaw Bay presettlement vegetation key. (Dashed line indicateds 585 ft contour).

transplanting of wetland plants are not included in the design. Succession on wet meadow sites appears to be related to depth to ground water. Sites with the water table within 10 cm of the surface in late summer will support obligate wetland species such as *Iris versicolor* and *Acorus calamis* and will be dominated by *Carex/Calamagrostis*, patches of prairie cord grass and the invasive reed canary grass. A mix of facultative wetland and upland species dominate areas with depth to groundwater in late summer > 50 cm.

Data from these representative marshes need to be expanded to a seasonal basis and need to be correlated to hydrology, soils, or elevation for the vegetation and to these same parameters plus vegetation-type for the fauna to allow prediction of the type of wetlands that can be expected on restored areas. We plan to include such studies in our future efforts and also plan to conduct a series of experimental studies to determine ways to enhance recovery of restored areas. Current lake levels are similar to historic levels and the potential for restoration of some of the 70% of the area that was converted is great.

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WETLAND RESTORATION AND MANAGEMENT IN THE CITY OF WEST PALM BEACH, FLORIDA, WATER RESOURCES PROGRAM

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The City of West Palm Beach, Florida is the only large southeast Florida municipality that uses a surface source of potable water. The City's water supply system consists of a 19.3 square mile Water Catchment Area (WCA), which captures rainfall and stores water pumped from a major canal that flows from Lake Okeechobee; the M Canal, which conveys water from the WCA to Lake

Mangonia and Clear Lake; and a water treatment plant that withdraws water from Clear Lake (Figure 1). The City has embarked on a long-range water resources program to ensure that the quantity and quality of water will be adequate to meet the goals of potable water supply and environmental preservation and restoration. Elements of the water resources program that relate to restoration and management of wetlands include: restoring base flow in Loxahatchee Slough, which feeds the federally-designated wild and scenic Loxahatchee River; creation of a wetland buffer system around the WCA; use of reclaimed wastewater and stormwater to restore wetland hydroperiods in the buffer system; eradication of exotic vegetation; and management of the WCA and buffer system to maintain wildlife habitat.

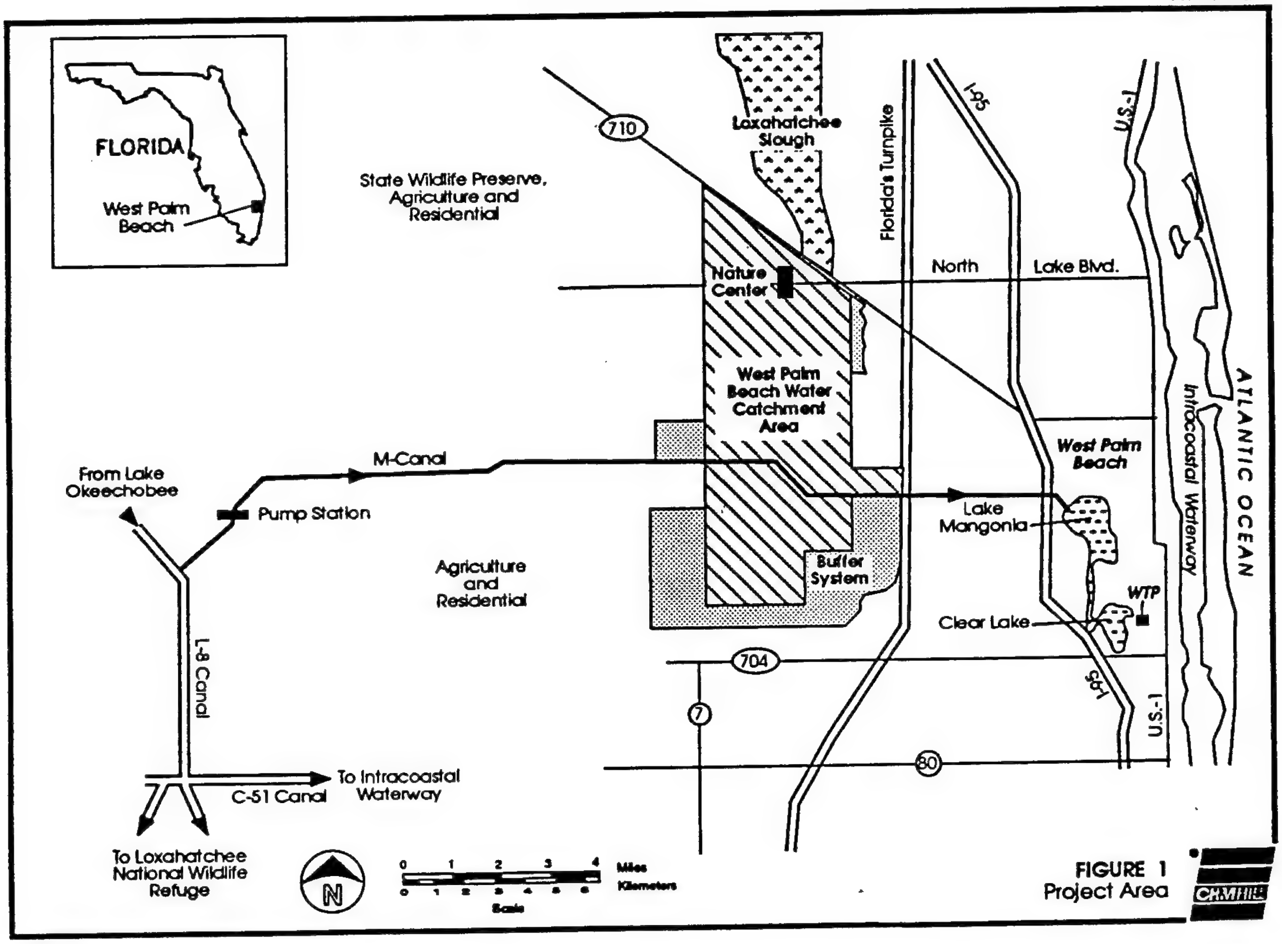

FIGURE 1
Project Area

Development and alteration of flow patterns have reduced base flows in the Southwest Fork of the Loxahatchee River, which has allowed salt water to move upstream, converting cypress swamps to mangrove forests. As part of a regional flood control and environmental restoration project, the City is working with the South Florida Water Management District to use the WCA to augment base flow in Loxahatchee Slough without increasing peak flows. This cooperative effort also includes development of a model that

will be used to manage water levels and flows in the WCA, based on considerations of potable water supply, maintenance of wetland communities and wildlife habitat in the WCA, and enhancing base flow in Loxahatchee Slough.

The City is creating a buffer system around the south end of the WCA through land acquisitions and dedication of conservation easements. Many of the seasonally wet emergent marshes in the buffer lands have been altered by drought and lowered groundwater tables, which have allowed melaleuca trees (Melaleuca quinquinervia) to become established. Management plans for those wetlands include initial removal of melaleuca, and restoration of historic hydroperiods using reclaimed wastewater and/or stormwater run-off from adjacent lands. Constructed wetlands will be created in areas of melaleuca monoculture to provide storage and water quality improvement for the supplemental water sources, as well as to create additional wetland area. Less dense melaleuca will be eliminated using manual removal of small trees and chemical treatment of larger trees.

Restored hydroperiod in the buffer wetlands will help prevent the re-establishment of melaleuca, and it will improve wildlife habitat for wetland-dependent species. The WCA and nearby wetlands provided a refuge for endangered snail kites (Rostrhamus sociabilis) during droughts in the 1980s, when traditional habitat in the Everglades was too dry to support the apple snails that are the kite's primary food (Takekawa and Beissinger 1989); snail kites have continued to nest and feed in the WCA since then. Other protected birds that have been documented in the WCA or adjacent wetlands include wood stork (Mycteria americana), little blue heron (Egretta caerulea), and tricolored heron (Egretta tricolor).

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SOIL AS A BIOLOGICAL INTERFACE IN WETLAND CONSTRUCTION

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The author reviews the importance of the soil substrate as a critical component of a wetland ecosystem. The geotechnical aspects of soils are acknowledged as critical to the success of wetland restoration and construction. Nevertheless, in order to

balance the discussion of soils in the context of the constructed or restored wetland setting, the importance of the biological aspects of soils also must be addressed in the wetland planning process. In most cases, the biochemistry and ecology of functioning wetland systems are driven largely by processes associated with wetland soils.

Substrate is critical to the success of the project and the potential functions that can be provided by the wetland system. It is imperative that persons involved in this applied science be cognizant of both the engineering and biological functions of soils as unique but interconnected components of wetland systems. To reinforce this concept, the author suggests that practitioners of wetland science differentiate between soils as structural components of constructed wetlands and soils as biological activity sites.

Two different yet parallel definitions of wetland soil components are offered. It is suggested that the physical properties (geotechnical engineering aspects) of the soils as they apply to site selection and construction be referred to as SUBGRADE elements of the wetland system. Soil chemical and biological properties influence the types of plant communities and other organisms that are planned and anticipated in restored and constructed wetland systems. These properties are recognized as being part of the matrix that provides physical support and anchoring of plants, a medium for macro- and micro-invertebrates, support of microbial communities, and a source/gradient through which nutrients are supplied for plant growth.

The author suggests that the term soil SUBSTRATE be applied to identify the medium that performs these biological functions in wetland systems. Characteristics of functioning wetland substrates are discussed briefly as are strategies to ensure that these same functions are duplicated in the substrates of constructed and restored wetland systems to the fullest extent possible. Organic vs. mineral substrates are discussed, and cautions are offered regarding the application of organic amendments to constructed wetland substrates. The advantages and disadvantages of various potential substrate materials are presented.

Additional research is needed to expand our understanding of the complexity and importance of constructed wetland substrates and to help us establish "mileposts" by which we can gage our success in creating wetlands that readily assume a productive role in local ecosystems. Gone are the days of "let's make it wet and see what happens." Although this axiom is still likely to be playing in the back of some minds, we owe it to our discipline and our science to be able to say how we will make it wet, how we will keep it wet, what it will look like, and what we expect it to do.

SESSION CW1

CONSTRUCTED WETLANDS: WATER AND WASTEWATER TREATMENT
Tommy E. Myers, Chair

CONSTRUCTED WETLANDS FOR STORM WATER MANAGEMENT ON ARMY INSTALLATIONS

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Storm water management is critical to overall water quality. The Clean Water Act includes regulations and required plans intended to improve the nation's water quality by addressing nonpoint (diffuse) sources of pollution--the last major water pollutants left in the country.

U.S. Army installations control and mitigate these industrial pollutants through an active pollution prevention program that includes training and education, a bite-specific storm water pollution prevention plan, and extensive Best Management Practices (BMPS). The U.S. Army Construction Engineering Research Laboratory (CERL) is studying constructed wetlands as an innovative BMP to enhance water quality from storm water run-off on installations.

A constructed storm water wetland is a system designed to mitigate the impacts of storm water run-off quality and quantity, It does so by temporarily storing storm water run-off in shallow pools that create growing conditions suitable for emergent and riparian wetland plants. The run-off storage, complex microtopography, emergent plants, and detritus in the storm water wetland together form an ideal matrix for removing pollutants. It does this through a series of complementary physical, chemical, and biological pathways: sedimentation; adsorption to sediments, vegetation, and detritus; physical filtration of run-off; microbial uptake and transformation; uptake by wetland plants; uptake by algae; and extra detention and/or retention. These systems' performance, under widely different environmental and run-off conditions has been well documented by research.

Constructed wetlands are being used worldwide for a variety of functions. These include treating wastewater streams (domestic, industrial, mining, agricultural, storm water), polishing effluents, enhancing esthetics, providing fish and wildlife habitat and replacing other wetlands.

U.S. Army installations, both small and large, could benefit from constructed storm. water wetlands. Larger installations function like a comparably sized city complete with utilities and amenities. But unlike a city, the Army has excellent control over its real estate and over the behavior of individuals working and living there. Activities like littering and random dumping of trash are rare. Real estate is maintained and the Army is proactive in complying with environmental laws.
within this environment, constructed wetlands could reduce storm water run-off while improving its quality. Target areas on Army installations for treatment by constructed Wetlands include the cantonment (the city proper region); motor pools contaminated with hydrocarbons, trace metals, and sediment,- open burn/open detonation sites; airfields that service rotary and fixed-wing aircraft; training ranges; and more.

Storm water wetlands are very distinct from undisturbed natural wetlands in hydrology, morphology, and ecology. An understanding of these differences is important in designing the storm water wetland.

Constructed storm water wetlands also must address the concerns of adjacent residents. The designer must consider social factors such as mosquitoes and odors, safety, appearance, passive recreational use, access, and maintenance. Operational aspects must be included. For example, on an airfield, will aircraft be jeopardized by migratory waterfowl or other birds attracted to the area? The designer's challenge is to construct a system that simultaneously mimics the functions of a natural wetland yet fully addresses the needs and concerns of the surrounding community.

For more information on storm water wetlands, contact the author at 217-373-3488 or toll-free 800-USA-CERL.

BIODENITRIFICATION OF FRESH WATER BY CONSTRUCTED WETLANDS

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Abstract

Fresh water supplies are susceptible to nitrate contamination from sources including agricultural and industrial operations, and domestic septic tank drainfields. In South- Central Arizona, contaminated groundwater aquifers can have nitrate-nitrogen concentrations ranging from 15 mg/l to more than 400 mg/l, depending on the source of contamination. Surface water is

conveyed by a canal system, from several major river watersheds, to the metropolitan areas located in the southern part of the state. Along the canals, groundwater is pumped from nitrate-contaminated aquifers to partially replenish the supplies for downstream reuse, increasing nitrate concentrations as the water flows along the length of the canal system. Biodenitrification wastewater treatment technologies, such as constructed wetlands, are being designed for treating fresh water contaminated by nitrates. The basic treatment process requires creating anoxic treatment zones in which nitrate-contaminated water and available carbon sources are delivered to support respiration and growth of denitrifying bacteria.

Introduction

Biodenitrification processes applicable to constructed wetlands, were reviewed to develop a treatment process for reducing nitrate concentrations in surface and ground water sources. The goal was to increase treatment efficiency as compared with a conventional free water surface (FWS) constructed wetland and reduce land area requirements. The selected treatment process had to decrease construction and operating costs.

Constructed wetlands are defined as an artificial or engineered complex of saturated substrates, emergent and submergent vegetation, animal life, and water simulating natural wetlands for human use and benefits (EPA and Bechtel, 1994).

Process Selection

Suspended-growth and fixed-growth biological treatment processes were considered, in FWS and subsurface flow system (SFS) configurations. An aesthetic appearance and the feasibility for limited public access, were considered desirable characteristics for siting flexibility. A fixed-growth process was selected for its aesthetic appearance.

A hybrid SFS/FWS system configuration was developed to incorporate the aesthetic characteristics of an FWS with a higher efficiency SFS constructed wetlands. A SFS achieves increased efficiency by physical delivery of the required nutrients (a carbon source and nitrates) to fixed-growth denitrifying bacteria, rather than relying primarily on diffusion as in an FWS wetland.

Discussion

Raw water samples must be analyzed to determine seasonal characteristics, and for establishing design criteria. The pH of the untreated water should be in the range of 7.0 to 8.0 (Tchobanoglous, G., and Burton, F.L. 1991) or buffered to that range, as alkalinity in the treated water increases with the conversion of nitrate to gaseous nitrogen compounds. Denitrifying

bacteria respire gaseous compounds (NO, N2O, N2 and CO2), which bubble up through the treated water and escape to the atmosphere. Nutrient supplements including dissolved carbon (BOD) and trace phosphorous, are required to sustain denitrifying bacteria in an anoxic environment.

The rate of biodenitrification decreases with colder water temperature, decreased quality and concentration of BOD, and lack of available trace nutrients. A high quality, BOD source sustains a higher rate of denitrification. Three common supplemental BOD sources, listed in decreasing quality are methanol, acetate, and decomposed natural organic matter.

The hybrid FWS/SFS Constructed Wetlands configuration includes sedimentation, off-line flow equalization, return flow pumping, FWS/SFS treatment, FWS polishing, and slow-sand filtration. FWS/SFS treatment modules use a split-stream concept to treat a portion of the delivered flow in a permeable SFS bed. The SFS zone of the treatment module incorporates a subsurface flow distributor to reduce dissolved oxygen concentrations, a nutrient distributor, a permeable anoxic zone in which various wetlands plants (bulrush, etc.) are rooted forming an environment for denitrifying bacteria, and a subsurface flow collector zone. The remaining water flows through emergent plant growth and plant detritus in the FWS. Following biodenitrification, the surface and subsurface flows are mixed, and then can either be directed to a subsequent FWS/SFS treatment module or discharged to a polishing pond.

Conclusion

The hybrid FWS/SFS Constructed Wetlands provides a reliable, reduced cost alternative for biodenitrification of nitrate-contaminated surface or ground water, in a flexible configuration adaptable to various sites and topography.

Acknowledgments

This work was partially funded by the City of Avondale, Arizona, as a feasibility study for a constructed wetlands in a residential development, under the State's Storage and Recovery Act.

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SUGARCANE FACTORY WASTEWATER TREATMENT IN A DIKED WETLAND

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This study is focused on a diked natural wetland in Louisiana which has been used as part of an inexpensive treatment system for sugarcane factory effluent. Louisiana sugar factories process sugarcane seasonally, producing wastewater from October through December. The heavy solids are removed by sedimentation, then the wastewater is discharged to the diked wetland where it is stored until it is discharged to a bayou by April. The wetland was monitored 3 to 6 months for three grinding seasons. Sedimentation and decay removed more than 95% of the BOD and suspended solids from the wastewater which entered the wetland by the end of the grinding season. The dissolved oxygen concentration in the wastewater was low during the grinding season and it remained low in the stored wastewater. Water pH in the wetland recovered quickly during the grinding season to about 7.0.

To evaluate the wetland's ability to remove nutrients, nitrogen in the forms of total Kjeldahl nitrogen (TKN), ammonia, and nitrate, and total phosphorus (TP) were monitored. This study shows that removal of nitrogen and phosphorus in the wetlands varies seasonally. Conversion of ammonia to nitrate ion started in April, Part of the organic nitrogen was quickly removed from the water by sedimentation. In addition, ammonia is likely to adsorb to the soil. Denitrification was delayed by cool water temperature until the wetlands were nearly empty. Plants took up some nitrogen but without harvesting during the growing season the nutrients would be released back to the wetland water due to decomposition of dead plants and litter; this made annual nitrogen removal small. Phosphorus removal in this wetland treatment system was limited. Even long after the grinding season ended, phosphorus remained in the wetland water.

Damage to wetland trees may occur if flooding depth, duration and frequency exceed the tolerance limits of the vegetation. While it is difficult to quantify the flooding tolerance of the vegetation, early discharge of wetland water would decrease flooding damage. To enable discharge of treated effluent from the wetland at an early date an aeration station was built near a wetland outlet. An aerated effluent meets LADEQ discharge requirements and reduces impact of wetland discharge on receiving water. The aeration system was a simple and feasible engineering

approach which increased the dissolved oxygen in the effluent and allowed early discharge from the wetland.

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SESSION SM5

STEWARDSHIP AND MANAGEMENT: FISH AND WILDLIFE HABITAT MANAGEMENT I

Chester O. Martin, Chair

A SYNOPSIS OF STEWARDSHIP AND MANAGEMENT DEMONSTRATION STUDIES FOR THE CORPS OF ENGINEERS WETLANDS RESEARCH PROGRAM

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Because most U.S. Army Corps of Engineers (CE) projects occur along major waterways, they constitute important landscape features on local, regional, and national scales. These projects often have a human-induced aquatic-terrestrial interface where the natural wetland zone is stressed, reduced, or missing altogether. These circumstances provided an opportunity for investigators to conduct field studies to demonstrate improved stewardship and management on project lands as part of the CE Wetlands Research Program.

Interdisciplinary teams designed and implemented studies on wetland stewardship and management demonstration sites throughout the United States, with emphasis on the Mississippi and Missouri River systems. Demonstration studies were organized into 8 research areas representing different disciplines involved in wetland management. Topic areas investigated were non-point source pollution (NPSP), sediment management, vegetation management, pest management, wildlife habitat management, fisheries habitat management, and natural communities/ biodiversity management.

Demonstration sites were located at the following CE projects: Bowman Haley Reservoir, ND; Ray Roberts Lake, TX; Grenada Lake, MS; Black Butte Reservoir, CA; Harry S. Truman Reservoir, MO; Riverlands Environmental Demonstration Area, MO; Tuttle Creek Lake, KS; Sayers Reservoir, PA; Green Peter Reservoir, OR; Conesus Lake, NY; Buzzard Bayou, MS; Grassy Lake, LA; Lake Okeechobee, FL; Lake Traverse/Mud Lake, MN; Upper Mississippi Pools, MN; and Lake Sakakawea/Williston, ND. Additionally, aquatic biodiversity study sites included Big Cypress Bayou, TX, and two creek systems of the Alabama River, AL.

NPSP and sediment management studies were designed to measure and analyze sedimentation, nutrient levels, and contamination, primarily in constructed wetlands. Atrazine was detected at several locations; thus, mesocosm studies were conducted to determine atrazine retention and degradation in wetlands. This work was accomplished in controlled experiments at the CE Lewisville Aquatic Ecosystem Research Facility, TX.

Vegetation management studies were conducted in cooperation with the Natural Resources Conservation Service (previously Soil Conservation Service) Plant Materials Centers. Emphasis was on vegetation establishment and management in reservoir drawdown zones. Planting trials and greenhouse studies were conducted at the Coffeeville, MS, Plant Materials Center. Pest management studies consisted of field testing control technologies for melaleuca (Melaleuca quinquenervia) and purple loosestrife (Lythrum salicaria). Chemical, mechanical, and biological treatments were investigated for these species in selected wetland systems.

Wildlife habitat management studies were designed primarily to evaluate techniques perceived to have high potential for improving wetlands for waterfowl habitat. Several studies focused on moist-soil management and its application to CE lands. Techniques such as mowing, discing, and burning were evaluated as methods useful for improving habitat diversity for waterfowl and other wetland species. Fisheries habitat management studies included investigations of aquatic areas and associated wetlands as reproductive habitat. At several sites, community composition and relative abundance of larval and adult fishes were compared between created/restored wetlands and adjacent natural systems. Biodiversity management studies were conducted for fish and wildlife in inland freshwater marshes and riverine systems.

Most of the demonstration site work was accomplished through extensive partnering with other agencies and organizations. Cooperators included 12 CE Districts, 8 other Federal agencies, 16 state and local governments, 18 universities, and 11 private organizations.

EARLY LIFE HISTORY OF NORTHERN PIKE IN ARTIFICIAL WETLANDS OF CONESUS LAKE, NEW YORK

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Four artificial wetlands were constructed adjacent to Conesus

Inlet Creek, largest tributary of Conesus Lake. The wetlands were designed to serve as northern pike spawning and rearing habitat. Fishes were collected during the spawning and rearing seasons of 1992, 1993, and 1994 in artificial wetlands, natural wetlands, and Conesus Inlet Creek. Our objectives were to evaluate early life history of northern pike including reproductive success in artificial and natural wetlands, emigration from spawning wetlands, and interactions between larval northern pike in the wetlands. In 1992 fishes were collected using a trap/dip net combination which provided a direct measure of population density. In 1993 and 1994 fishes were collected with larval light traps which provided a relative measure of abundance and sampled a wider range of habitat types than the trap/dip net combination. In 1994 behavior of larval northern pike was observed in artificial wetlands and in experimental arenas to assess intraspecific interactions and migration behaviors.

Density of pike was greatest in late April and declined afterward in all wetlands. Mean peak density was significantly greater in artificial (29.6 pike/sqm) than in natural (11.6 pike/sqm) wetlands. Mean length of pike at that time was also significantly greater in artificial wetlands (11.3 mm) than in natural wetlands (10.1 mm). Density in Conesus Inlet increased steadily through the spring as pike emigrated from wetlands to the lake. Pike began to exhibit behaviors associated with migration ie. deliberate straight line movement, at approximately 14 mm total length. Pike as small as 14 mm total length emigrated from wetlands into Conesus Inlet Creek. While observing 103 larval northern pike, ninety three interactions between larval pike were observed in artificial wetlands. Seven distinct types of encounters were identified, one of which was aggressive and was observed one time.

This study indicates that shallow non-wooded areas with emergent grasses, sedges, and cattails provide ideal pike spawning habitat and that such areas can be constructed to meet spawning requirements of northern pike. To avoid stranding, artificial wetlands should remain flooded until larval pike reach a length of approximately 30 mm at which time most will have emigrated from the spawning wetlands. Wetlands should also slope gradually from shallow to deep water areas to avoid stranding as water levels drop. Larval northern pike should have access to deep water habitats from time of hatching until all have emigrated from the spawning wetlands. Transitional areas between spawning and deep water habitat serve as important rearing habitat and should be incorporated into an artificial wetland system.

RIVERINE-WETLAND CONNECTIONS AND
LARVAL FISH DYNAMICS OF BOTTOMLAND HARDWOOD SYSTEMS

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Different floodplain habitats were sampled in the lower Mississippi Basin: 1) connected and isolated backwater lakes including oxbows; 2) seasonally inundated fringes of rivers; 3) reconnected riverine backwater. Larval fishes were collected with Plexiglas light traps, and abundance related to hydrology, geomorphology, or water quality. Spawning chronology was: buffalo > darters > black bass > crappie > carps and shad > sunfishes > nearctic minnows. Spawning began and ended earlier in remote wetlands than in proximate wetlands or rivers. Relative abundance of larvae was highly variable among systems, but provided an opportunity to address four questions:

How do larval fishes differ in permanently connected and normally isolated backwater lakes? High densities of crappie, black bass, and sunfishes occurred in isolated wetlands. Migratory species, including those capable of maintaining lacustrine sub-populations, were uncommon or absent. These included shad, nearctic minnows, and buffalo.

How does frequency of flooding influence larval fishes in backwater lakes? Frequency of flooding was not associated with species richness of larval fish assemblages or with relative abundance of most taxa. Fish assemblages in an isolated oxbow were highly similar to those of a permanently connected oxbow, and both were disparate from that of a seasonally connected oxbow. Spatial distribution of larvae within each lake was non- uniform and varied among lakes, suggesting that habitat features were of greater importance to reproduction than flood frequency.

How do floodplain habitats differ in value for fish reproduction? A bottomland hardwood, connected oxbow, and tributary mouth supported higher densities and diversity of larval fishes than did agricultural and fallow fields. Assemblages in the agricultural field were dominated by larval buffalo and shad, but buffalo also occurred in all other habitats and densities in connected oxbows were nearly six times higher.

What variables are correlated with larval fish abundance? Larval fish of most taxa congregated at the riverine-wetland interface; few taxa predominated in remote parts of the wetland (threadfin shad) or in the river channel (blacktail shiner). Lateral and microhabitat segregation were pronounced, though. Sunfishes and darters occurred very close to shore, minnows and

gizzard shad farther from shore, crappie and black bass farther still, and threadfin shad offshore. Minnows and crappie abundances were correlated with turbidity and total dissolved solids, darters with submersed cover, and sunfishes with total dissolved solids and dissolved oxygen.

Several micro- and macrohabitat variables are correlated with abundances of individual taxa of larval fishes, but riverine-wetland connection may provide better characterization of larval fish assemblages. Larval fish are more abundant in permanent floodplain waters, than those that are seasonally inundated. Long-term isolation favors spawning success of recreationally important perciforms fishes, but is apparently deleterious to commercially important suckers. Seasonal interruption in riverine-wetland connections could enhance recreational and commercial fisheries, increase local biodiversity, and control noxious species. Connections early in the spawning season provide access for buffalo, black bass, and some darters; connections late in the season provide access for certain sunfishes and nearctic minnows. Mid-season isolation restricts influx of native forms prone to overcrowding (bluegill, gizzard shad) and exotic species (Asian carps).

MANAGEMENT OF SHALLOW IMPOUNDMENTS TO PROVIDE EMERGENT AND SUBMERGENT VEGETATION FOR WATERFOWL

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Effects of partial drawdowns, drawdown timing, and tilling on vegetation and seed production for waterfowl were tested in ponds at the Lewisville Aquatic Ecosystem Research Facility in north-central Texas. Four ponds were utilized to provide 3 replicate ponds and 1 control pond for each treatment. Vegetation lists, percent cover (PC), and above-ground biomass (AGB) revealed that partial drawdowns produced a typical zonation of wetland plants: submergent macrophytes in deep-flooded zones; cattail (Typha sp.), black willow (Salix nigra), and sedges in shallow-flooded zones; forbs in moist zones adjacent to water; and, grasses in upper, drier zones. Seed production of grasses, sedges, and forbs generally reflected the vegetation present in each

soil-moisture zone. Taxon richness of emergent plants was highest in dewatered zones.

Drawdown timing did not affect taxon richness of emergent plants within dewatered zones, but grass AGB, and forb and sedge PC and AGB were highest during 1993 spring drawdown. The majority of grasses and forbs had higher seed production during 1992 late-summer/early-fall drawdown whereas sedges produced more seeds during the spring drawdown. Black willow occurred most frequently and cattail was first recorded during spring drawdown. Most submergent macrophytes were unaffected by drawdown timing.

Soil disturbance with rototilling created diversity in ponds by increasing taxon richness of emergent plants, encouraging annuals, and discouraging perennials. PC, AGB, and seed production of forbs and grasses generally increased and decreased, respectively, with tilling, whereas sedges were not affected. Cattail and black willow occurred most frequently in tilled areas. Most submergent macrophytes were not affected by tilling, except southern naiad (Najas guadalupensis), with higher PC in tilled plots.

Finally, observations revealed that waterfowl visiting ponds utilized regions according to water depth and plant communities. Gadwall (Anas strepera) and American wigeon (A. americana) were most often observed within deep zones supporting submergent vegetation. Although data were not statistically significant, blue-winged teal (A. discors) and green-winged teal (A. crecca) occurred most often in shallow zones supporting emergent vegetation and seeds. Therefore, partial drawdowns, variations in drawdown timing, and soil disturbance, were effective in providing a variety of vegetation and seeds for a diversity of migrant and wintering waterfowl.

WILDLIFE HABITAT FUNCTIONS IN CREATED WETLANDS

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In the winter of 1991-92 the flow of Spring Creek was diverted through a 21-acre created wetland in an effort to improve the quality of water entering Bowman-Haley Reservoir, ND. The created wetland was designed to maximize shallow-water habitats for use by migratory and breeding waterbirds. In the spring of 1992 data collection was initiated to gather information on waterbird use of Spring Creek and the created wetland. Wildlife use was documented through monthly surveys (May - August) during the 1992 and 1993 field seasons. All wildlife use of the wetland and Spring Creek for 2 km upstream from the wetland was recorded.

Waterbird surveys indicated that the created wetland provided pairing habitat for at least 14 pairs of ducks, and brood-rearing habitat for at least 5 duck broods in 1992, and at least 45 pairs and 14 broods in 1993. In comparison, a 2-km segment of Spring Creek upstream from the created wetland provided habitat for only 5 pairs of ducks, and no broods. Avian species diversity also increased through time in the created wetland.

The created wetland also provided habitat for large numbers of shorebirds during both spring and fall migration, including the endangered interior least tern. However, many species indicative of mature wetlands have been absent; these include red-winged and yellow-headed blackbirds, long-billed marsh wrens, and American bitterns. As the wetland matures and permanent emergent vegetation is established, a more diverse wildlife community should appear.

1992 WATERFOWL PAIR AND BROOD DATA ON SPRING CREEK CREATED WETLAND, BOWMAN-HALEY RESERVOIR, NORTH DAKOTA

SPECIES	DATE 15 MAY Pr	Br	30 JUNE Pr	Br	22 JULY Pr	Br	10 AUGUST Pr	Br
Mallard	5	0	3	1	0	3	0	4
Northern Pintail	0	0	1	0	0	1	0	0
Gadwall	2	0	0	0	1	1	0	1
Blue-winged Teal	4	0	0	0	0	0	0	3
Wood Duck	1	0	0	0	0	0	0	0
Canada Goose	1	1	0	0	0	1	0	0
Total Waterfowl	13	1	4	1	1	6	0	8

1993 WATERFOWL PAIR AND BROOD DATA

SPECIES	13 MAY Pr	Br	26 JUNE Pr	Br	24 JULY Pr	Br	17 AUGUST Pr	Br
Mallard	7	0	6	1	0	3	0	2
Northern Pintail	1	0	1	0	0	1	0	0
Gadwall	6	0	7	0	0	3	0	3
Blue-winged Teal	9	0	12	0	0	4	0	3
Green-winged Teal	5	0	5	0	0	1	0	0
Northern Shoveler	6	0	4	0	0	0	0	1
American Wigeon	3	0	6	0	0	0	0	0
Redhead	0	0	2	0	0	0	0	0
Lesser Scaup	2	0	1	0	0	0	0	0
Ruddy Duck	0	0	1	0	2	0	0	1
Total Waterfowl	39	0	45	1	2	12	0	10

BIRDS OBSERVED UTILIZING SPRING CREEK CREATED WETLAND

Pied-billed Grebe	Eared Grebe
Wilson's Phalarope	Greater Yellowlegs
Black Tern	Long-billed Dowitcher
Interior Least Tern[a]	Spotted Sandpiper
Forester's Tern	Sandhill Crane
Ring-billed Gull	Northern Harrier
American Avocet	Cliff Swallow
White Pelican	Barn Swallow
Marbled Godwit	Northern Rough-winged Swallow
Willet	Bufflehead
Long-billed Curlew	Great Blue Heron
American Coot	Canvasback

[a] Interior Least Tern is a federally listed endangered species.

Verification of this species at the Spring Creek created wetland is the first record for least terns at the Bowman-Haley Project.

SESSION MB2

MITIGATION AND MITIGATION BANKING: STRATEGIES IN MITIGATION I
Ms. Lynn R. Martin, Chair

A MITIGATION BANKING PROPOSAL FOR THE PLAYA VISTA PROJECT, LOS ANGELES, CA

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Maguire Thomas Partners-Playa Vista is constructing a 51.1-acre freshwater wetland system and proposing to restore a 191- acre salt marsh system in Los Angeles, California. The Corps of Engineers and California Coastal Commission permits to construct the freshwater wetland system recognize that this system will be used to offset the loss of approximately 24 acres of largely man-made wetlands that could be filled to construct a proposed mixed use development at Playa Vista. The permits also provide for the possibility that a restored salt marsh could be used as a mitigation bank for other projects. Permits for the mixed use development have not been granted. To ensure that this new freshwater wetland system will indeed meet the policy of no net loss of wetlands, Maguire Thomas Partners-Playa Vista has agreed, among other things, that the new wetland system would be established prior to the destruction of other wetlands on site; that the new wetland system would be managed, maintained and remediated in perpetuity; and that plans and funding for restoration of an adjoining 191-acre salt marsh would be completed. This paper discusses the mitigation strategy developed for this project, the limitations imposed by the permitting and resource agencies on this strategy, and the applicability of this strategy to other projects.

FLORIDA'S FIRST FULLY-ENTREPRENEURIAL WETLAND MITIGATION BANK

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The southeastern coastal plain of the United States has abundant wetland resources. These resources frequently comprise 25-35% of the landscape and the wetlands are scattered throughout the landscape. Many private and public development activities require wetland permits. Wetland creation has been much maligned and is very expensive to make work successfully. In late 1993, prior to promulgation of Florida's mitigation banking rule, Mitigation Solutions, Inc. began a search for a privately-owned and operated mitigation bank to restore a 400-acre dairy which comprised mostly wetland soils. This paper discusses the site selection process and permitting effort for the first totally private, wetland mitigation bank permitted for construction under the new rule. Landscape Ecosystem Classification (LEC) and the Hydrogromorphic Method (HGM) were used to assess the site and determine mitigation value of the site, and the project was permitted pursuant to Florida's new mitigation banking rule criteria.

INTEGRATION OF WETLAND RESEARCH AND MONITORING INTO THE WETLAND MITIGATION DESIGN PROCESS: A CASE STUDY

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Increasing growth at the Detroit Metropolitan Wayne County Airport created the need for facility expansion including the extension of existing runways, and construction of two new runways, a mid-field terminal and access roads, Over 300 acres of wetlands would be impacted by the proposed expansion. Regulatory agencies having jurisdiction over the proposed project required that 1,5 acres of wetland be created as compensation for each acre of

wetland that was impacted. A 900-acre site approximately 8 miles southwest of the airport was selected for the wetland mitigation project based on criteria including the presence of prior-converted farmlands, hydric soils, perennial water courses and relatively low population density.

The creation of over 450 acres of wetland mitigation area provided the opportunity to test a number of theories relating to hydrologic modeling, wetland hydrology, construction methods and revegetation techniques, This presentation will describe: 1) how a variety of hypotheses were incorporated into the wetland design and 2) the monitoring program that was developed to gather the data necessary to formulate conclusions regarding the success of different wetland creation techniques.

AN ECOSYSTEM APPROACH TO COMPENSATORY WETLAND MITIGATION

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In 1989, the North Carolina General Assembly ratified House Bill 3499 providing for the establishment of the North Carolina Highway Trust Fund. A portion of the Highway Trust Fund was allocated for the construction of a North Carolina Intrastate System. Recognizing the importance of US 64 to regional commerce, travel and the economic development of northeastern North Carolina, the General Assembly included US 64 on the Intrastate System and mandated the complete four-laning of US 64 from Raleigh to the coast. It was further specified that US 64 be included as freeway construction between I-95 and US 17. Given this mandate, the North Carolina Department of Transportation (NCDOT) developed construction plans for a four-lane divided highway on a new location from the US 64/258/NC 44 interchange south of Tarboro to a location west of Everetts (23 miles) at the US 64/SR 1405 interchange.

Environmental Services, Inc. (ESI) was retained by NCDOT to develop a mitigation plan for wetlands impacted by the US 64 construction (104.7 acres). In addition, this plan provides for wetland impacts due to the construction of a new interchange at the US 64/SR 1225 crossing (3.5 acres).

A systematic search of the Edgecombe, Pitt, and Martin County

areas was conducted to locate suitable lands for in-kind mitigation of project-related wetland impacts. Efforts were concentrated within the Tar River Drainage Basin in order to promote in-basin functional replacement for lost wetland functions. Six sites were evaluated for mitigation opportunities.

Based on the ecological evaluation of each mitigation site alternative and the requirement to provide spatial and functional replacement of wetland losses, the 593-acre Mildred Woods site and the 112-acre Huskanaw Swamp site provide the best potential for an ecosystem approach to mitigation. Both sites are located immediately adjacent to the proposed highway along existing ecological corridors.

The project team made detailed analyses of existing ecological and hydrological conditions to provide maximum assurance of project success. Using hydrological modeling (DRAINMOD), it has been predicted that wetland hydrology can be restored to 443 acres at the selected sites. Hydric soils mapping, Hydrogeomorphic Modeling (Brinson et al, 1994), and Landscape Ecosystem Classification (Jones et al, 1984) models were used to predict the extent of the wetland/upland ecotones and appropriate vegetation plantings. After analysis of all data, 399 wetland acres will be restored, 44 acres will be enhanced, and 56 acres will be preserved (McCrain 1994). The balance of the properties, comprising 233 acres of uplands, will also be restored and managed.

This mitigation plan provides for restoration, enhancement and preservation of contiguous natural wetlands, which will ensure the perpetual maintenance of characteristic wetland functions in this region. The integration of contiguous upland and wetland communities will enhance the value of site-specific resources. Future management by the N,C, Wildlife Resources commission will provide for continued improvement and protection of these communities.

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STRUCTURE AND SUCCESSES OF THE OHIO WETLANDS FOUNDATION'S CONSOLIDATED MITIGATION SYSTEM

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In 1992, the Ohio Wetlands Foundation (Foundation) was created by the Ohio Home Builders Association, and a formal partnership agreement was established with the Ohio Department of Natural Resources, Division of Wildlife (DOW). The US Army Corps of Engineers, Huntington District, the US EPA, the Ohio EPA and the US Department of the Interior, and Fish and Wildlife Service, have all provided guidance to ensure that the Foundation's system reflects current regulatory policies. Envirotech Consultants, Inc, (Envirotech) acts as consultants to the Foundation for technical aspects of site selection, general design, landscaping and monitoring.

The goal of the Foundation is to create large, diverse wetland ecosystems through the pooling of resources of entities who are authorized to mitigate wetland impacts under Section 404 of the Clean Water Act. This system provides an alternative when on-site mitigation is not feasible, Sites are selected jointly by Envirotech and the DOW, and a preliminary plan is prepared for review by the agencies. Upon its acceptance, the Foundation is authorized to reserve acreage for clients who are applying to fill wetlands and mitigate on a Foundation site, A final construction plan is prepared for agency review, and construction is initiated upon approval, After construction, the DOW accepts the site for perpetual maintenance; however, the Foundation provides monitoring over a five-year period.

The Foundation provides $1,000 per acre to the DOW's Wetland Habitat Fund for wetland-related activities. The Foundation has managed to keep costs per acre to $7,500 and $12,000 for the two sites which have been constructed. Low costs per acre are maintained primarily by utilizing strict site selection criteria. Sites are sought which are underlain by hydric soils, are restorable with minimal excavation and are easily flooded with the construction of a low berm. Sites are also sought which show evidence of an existing wetland seed bank. The Foundation and the DOW have a strong interest in creating native plant communities which were historically present. Replacement of habitat types filled is the primary goal for the Foundation sites. For both sites already constructed, the plans called for shrub and tree species to be planted, but emergent habitat was allowed to develop from the seed bank.

The first site, located at the Hebron Fish Hatchery in Licking County, Ohio, experienced its first growing season under wetland hydrologic conditions in 1994. Emergent habitat development was exceptional with a total of 80 hydrophytic plant species identified. Wildlife identified on the site included 58 bird species, 6 mammals, 1 reptile and 4 amphibians, highlights of which were Grus canadensis (sandhill crane) and Sistrurus ctenatus (eastern massasauga), The second Foundation site is located at the Big Island Wildlife Area in Marion County, Ohio. 1995 will be the first growing season for this site. As with the Hebron site, large areas of wetlands were documented in historical literature. An excellent seed bank is expected to be present based on existing wetland areas, and additional habitat for several wetland dependent bird species which are state rare and endangered will be created.

SESSION CP5

CRITICAL PROCESSES: WETLAND PROCESSES, SOILS DEVELOPMENT, CHEMISTRY, AND EROSION

Jack E. Davis, PE, Moderator

MONITORING THE PHYSICAL ENVIRONMENT OF LOW-SALINITY ROOTED AND BOUYANT MARSHES IN COASTAL LOUISIANA

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Monitoring of the physical environment in the low-salinity coastal marshes of the Louisiana Delta plain (soils, hydrological response and porewaters) is complicated in that two physically distinct marsh types are present: those marshes firmly rooted in a non-buoyant substrate and buoyant marshes, those that are not anchored. In the latter, the shallow substrate moves vertically in response to changes in ambient water levels. The exchange of both above- and below-ground is predictably altered in the buoyant marsh compared with the rooted type. Sediments and nutrients carried by surface waters will enter the two marsh types differently. Freshwater will circulate differently in the two marsh types.

Innovative monitoring techniques are required to assess the response of both marsh types in rapid regional subsidence and gradually increasing salinities. In this communication, techniques used to describe and interpret mat buoyance and movement, substrate composition, and porewater responses to open- water forcing are presented, using examples from an on-going three-year interagency study of the intermediate marshes at Jean Lafitte National Historic Park and Preserve, Barataria Unit by the US National Biological Service and the US Geological Survey. The techniques will assist in determining potential impacts of proposed freshwater, sediment, and nutrient diversions of the Mississippi River water on the fresh and intermediate marshes, as well as providing some means of assessing benefits accrued through restoration methods currently being applied coast-wide.

EVALUATION OF FOUR CHEMICAL EXTRACTANTS FOR METAL DETERMINATIONS IN WETLAND SOILS

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Hydric soils [soils formed by wetland conditions] have special characteristics compared to dry mineral soils. Soil color and mottling, which indicate the duration and depth of soil saturation, reveal the hydric condition. Wetland soils receive, hold, and recycle nutrients and other elements which are continually washed from upland regions. Due to the high organic matter content of wetland soils, they normally have a great capacity to complex or adsorb metals and organics, which is responsible for the wetland's potential for pollutant retention (Reddy 1993).

The purpose of this study was to evaluate the suitability of the four most common chemical extractants (Mehlich 1, Mehlich 3, 0.1M HCl, and DTPA) for the determination of metals in wetland soils (Mehlich, 1953, 1984, Lindsey and Norval, 1978).

Constructed wetland cells were lined with 15cm of coal mine spoil from Tennessee and Alabama, or with topsoil from the study area (Abernathy silt loam). The replicated substrates, in separate cells, were saturated with water and planted with the following wetland plant species: cattail (*Typha latifolia*), maidencane (*Panicum hemitomon*), pickerelweed (*Pontederia lanceolota*), and bulrush (*Scirpus validus*).

Soil/spoil samples were extracted and analyzed for metal concentration using the following chemical extractants: Mehlich 1 (at a 1:4 soil/solution ratio); Mehlich 3 (at a 1:10 soil/solution ratio); 0.1M HCl (at a 1:10 soil/solution ratio); and DTPA (at a 1:2 soil/solution ratio). Plant shoots were cut at water level, dried, ground and digested with sulfuric acid and hydrogen peroxide. Mehlich 3 extracted higher quantities of Zn, Ni, Fe, Mn, Cr, Al, Ca, and Mg from topsoil. 0.1M HCl extracted more Pb, Cd, Cr, and Cu (Table 1). All extractants removed very small or zero amounts of Ni, Cr, Pb, and Cd from topsoil. Extractants generally followed the order of - Mehlich 3 > 0.1M HCl > Mehlich 1 > DTPA - with regard to removing most of the metals except for Pb, Cu, and Cd. However, statistically there were no significant differences among Mehlich 3, 0.1 M HCl, and Mehlich 1 extractant except for Al, Fe, and Cu.

A trend similar to that in topsoil was found with regard to the extraction of metals from Alabama and Tennessee spoils. Mehlich 3 was most effective for removal of most of the metals,

TABLE 1. Concentrations of Three Soil/spoil Materials by Four Extractants (June 1994).[a]

Soil/spoil	pH	Extractant	Zn	Pb	Cd	Ni	Fe	Mn	Cu	Cr	Al	Ca	Mg	K
								mg/kg						
Top soil	5.4	Mehlich 1	1.45 a*	0.35 a	0.08 a	0.47 a	197.7 a	199.0 a	1.00 a	0.20 a	170.0 b	390.0 a	33.0 a	29.0 b
		Mehlich 3	2.70 a	— ‡	—	0.50 a	264.8 a	279.7 a	1.00 a	—	310.7 a	516.3 a	49.7 a	109.0 a
		0.1M HCl	1.92 a	0.93 a	0.17 a	0.49 a	260.1 a	240.9 a	1.88 a	0.28 a	223.0 ab	419.0 a	41.4 a	32.0 b
		DTPA	0.28 b	0.67 a	—	—	11.3 b	22.6 b	0.12 a	0.01 a	0.7 c	—	0.63 b	—
Alabama mine spoil	5.8	Mehlich 1	1.60 a	0.81 a	0.04 a	1.30 a	199.0 a	172.0 a	0.70 a	0.10 a	148.0 a	198.0 b	69.0 a	23.7 b
		Mehlich 3	2.70 a	—	—	1.60 a	277.7 a	234.7 a	1.00 a	—	220.2 a	451.8 a	88.5 a	79.3 a
		0.1M HCl	2.20 a	1.20 a	0.06 a	1.42 a	266.7 a	213.0 a	1.90 a	0.18 a	169.8 a	231.0 b	74.0 a	33.7 b
		DTPA	0.33 b	1.83 a	—	0.17 b	43.2 b	45.8 b	0.90 a	—	22.2 b	—	9.3 b	2.0 c
Tennessee mine spoil	4.5	Mehlich 1	2.90 a	0.94 a	0.05 a	1.15 a	183.0 a	21.0 b	1.90 a	0.07 a	200.0 a	161.0 b	57.0 a	32.7 b
		Mehlich 3	4.80 a	—	—	2.00 a	289.0 a	88.2 a	1.50 a	—	270.2 a	367.7 a	74.3 a	106.7 a
		0.1M HCl	3.90 a	1.50 a	0.10 a	1.70 a	201.0 a	36.7 b	2.20 a	0.10 a	228.0 a	176.0 b	64.3 a	35.0 b
		DTPA	2.67 a	1.83 a	—	1.00 a	57.7 b	31.0 b	1.30 a	—	270.2 a	—	5.2 b	3.2 c

a Data points represent the average of three replications.
‡ Not detectable
* Means followed by the same letter in each column within each soil/spoil are not significantly different at the 5% level (Tukey's test).

i.e. Zn, Ni, Fe, Mn, Al, Ca, Mg, and K. In general, DTPA was more effective and removed greater quantities of metals from Tennessee spoil than from Alabama spoil or topsoil. This may be due to the lower pH of the Tennessee spoil. Cadmium, Ni, and Cr concentrations were very low with all extractants. All of the extractants did not correlate with the plant concentration of these metals.

The results of this study showed the complexity and dynamics of metal removal by aquatic plants and chemical extractants from hydric soil. However, the search for an appropriate extractant for routine metal determination of hydric soils is warranted. Mehlich 3 was clearly the most effective in extracting most of the metals in this study, although it did not have the highest correlation with uptake levels in the selected plant species.

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THE USE OF SOIL MORPHOLOGICAL FEATURES TO PREDICT HIGH GROUND WATER TABLES IN PROBLEMATIC SOILS OF SOUTHERN NEW ENGLAND

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The use of soil morphological features to infer soil moisture regime is a practice widely used for urban land use interpretation

and the identification and delineation of jurisdictional wetlands. Numerous studies have quantitatively examined the complex interrelationships between soil morphology and hydrology in a number of geologic settings. In New England, various problematic soils occur in Wisconsinan age sediments which do not adhere to standard morphological criteria relating soil color to wetness due to regional differences in bedrock geology or depositional environment (Tiner and Veneman 1987). These soils include soils developed from coarse-textured glacial fluvial sediment which weakly express wetness morphologies; and soils formed in low chroma Carboniferous lodgment till which are inherently gray in color and masks hydromorphic features. Studies were conducted in Rhode Island to examine the physical, chemical, and morphological properties of these problematic soils to determine if there were any relationships which could be used to predict high ground water tables.

Fifty-four soil profiles were investigated at nine hydrosequences developed in coarse-textured, stratified glacial fluvial sediment (Sokolosld 1988); and 19 soil profiles were investigated at four hydrosequences formed in low chroma glacial till developed from Carboniferous parent materials of the Narragansett Basin of eastern Rhode Island (Lesinski 1994). Detailed morphological descriptions were obtained from each pedon, selected laboratory analyses were performed on each horizon or layer, and water tables were measured biweekly for approximately two years at each of the 73 sites. Twenty-one to 27 soil properties which have been shown in previous studies, or otherwise believed to be, related to high ground water levels were statistically analyzed using SAS stepwise regression technique to develop predictive equations (Table 1). The high water level variables used in these equations included those occurring during the growing season, or that period of the year when soil temperature at 50 cm exceeded 5′ Celsius as monitored at each pedon via thermisters.

Four soil properties were selected by stepwise regression as the best indicators of growing season high ground water tables in sandy, stratified glacial fluvial soils (Table 2). These four morphological properties explained 79% of the variability in water tables and included: depth to a chroma of 3 or less and value of 4 or more, thickness of an epipedon meeting umbric requirements, thickness of the B horizons, and thickness of the gibric organic (Oi) horizon. The single-best predictive soil property was the depth to a chroma of 3 or less and value of 4 or more, which exhibited a correlation coefficient of 0.825.

Three soil properties explained 85% of the variability of growing season high ground water tables in low chroma glacial till soils (Table 2). The morphological properties selected as best predictors of growing season high water tables were: depth to redoximorphic features from the bottom of the A horizon, value plus

Table 1. Soil Properties Examined for Significant Relationships to Growing Season High Water Tables		
Glacial fluvial sediments	Low chroma lodgement till	Soil Property
•	•	Combined thickness of all organic (O) horizons
	•	Thickness of hemic organic (Oe) horizon
	•	Thickness of sapric organic (Oa) horizon
	•	Thickness of Oe and Oa horizons combined
•	•	Thickness of O and surface mineral (A) horizons
•	•	Thickness of A horizon
•	•	Thickness of subsurface mineral (B) horizons
•	•	Thickness of the solum (A plus B horizons)
	•	Presence of epipedon meeting umbric requirements
•	•	Value of A horizon
•	•	Chroma of A horizon
•	•	Value plus chroma of A horizon
	•	Value:chroma ratio of A horizon
	•	Value of B horizon
	•	Chroma of B horizon
	•	Value plus chroma of B horizon
	•	Value:chroma ratio of B horizon
	•	Presence of a gleyed (g) horizon
•	•	Depth to any redoximorphic features
	•	Depth to horizon or layer meeting densic requirements
	•	Depth to matrix chroma of 1 or less
•	•	Depth to matrix chroma of 2 or less
•	•	Depth to common or many prominent redoximorphic features
•	•	Depth to matrix hue of 2.5Y, 5Y, or N
	•	Depth to redoximorphic features from the bottom of the A horizon
	•	Chroma index[1]
	•	Chroma:value index[2]
•		Organic carbon (g/m^3)
•		Thickness of fibric organic (Oi) horizon
•		Thickness of epipedon meeting umbric requirements
•		Free iron (g/m^3)
•		Depth to redoximorphic features of chroma 2 or less
•		Depth to redoximorphic features of chroma 3 or less
•		Depth to matrix chroma of 3 or less and value of 4 or more
•		Depth to many redoximorphic features
•		Depth to gleyed (g) horizon

[1]Chroma index: (Evans and Franzmier, 1988)

$$\sum_{i=1}^{m} = \frac{(\text{Abundance}^{\text{matrix}}) \times (\text{Chroma}^{\text{matrix}}) + (\text{Abundance}^{\text{redox}}) \times (\text{Chroma}^{\text{redox}})}{\text{Number of subsoil horizons}}$$

[2]Chroma:value index:

$$\sum_{i=1}^{m} = \underline{(\text{Abundance}^{\text{matrix}}) \times (\text{Chroma/Value}^{\text{matrix}}) + (\text{Abundance}^{\text{redox}}) \times (\text{Chroma/Value}^{\text{redox}})}$$

Table 2. Contributions of Soil Properties to Predictive Growing Season Mean High Water Table Model

Coarse-textured Glacial Fluvial Soils

Variable Selected	No. in Model	R^2
Depth to Chroma 3 or less and value 4 or more	1	0.68*
Thickness of epipedon meeting umbric requirements	2	0.73*
Thickness of B horizon	3	0.76*
Thickness of Oi horizon	4	0.79*

* Significant at the $P<0.05$ level

$$Y = 10.31 - 0.54 \text{ (Chroma} \leq 3) + 0.48 \text{ (umbric)} - 0.55 \text{ (B horizons)} - 1.53 \text{ (Oi horizons)}$$

Low Chroma Glacial Till Soils

Variable Selected	No. in Model	R^2
Depth to redoximorphic features from the bottom of the A horizon	1	0.673*
Value plus chroma of the B horizon	2	0.801*
Value plus chroma of the A horizon	3	0.850*

* Significant at the $P<0.05$ level

$$Y = -3.78 + 0.55 \text{ (Depth to redox features)} + 3.09 \text{ (Value plus chroma of B horizon)} - 2.33 \text{ (Value plus chroma of A horizon)}$$

chroma of the B horizon, and value plus chroma of the A horizon. The single best predictive soil property was depth to redoximorphic features from the bottom of the A horizon which exhibited a correlation coefficient of 0.820.

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REDOX POTENTIALS ACROSS A TRANSECT FROM HYDRIC TO NON-HYDRIC SOILS

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Introduction

The purpose of this study was to examine redox potentials across an undisturbed forested wetland to upland transect in Southeastern Louisiana to characterize the oxidation-reduction status of the soils. We used a large number of replicate electrodes at each site to examine what differences could be detected in soil redox potentials at three sites differing in elevation, and to look for seasonal changes in soil redox potential.

Materials and Methods

Bright-platinum electrodes were installed at three sites from a non-hydric soil (Site 1) to frequently flooded hydric soils (Site 3) with an intermediate site having occasionally flooded hydric soils (Site 2). Eight electrodes were installed at a depth of 15 cm and 30 cm in replicate plots in each site. Measurements were taken approximately monthly from December 1992 until September 1994. Significant differences in mean redox potential between sites at each depth were determined using SAS with a split-split plot design and multiple comparisons within depths between sites.

Results and Discussion

Mean redox potentials at the 15-cm depth in the three sites (Figure 1) were considerably different during most of the study. Site 1 consistently had higher mean redox potentials whereas the mean redox potential at Site 3 was lower than that of each of the other two sites. Redox potentials at Site 3 were significantly lower than those at Site 1 over most of the study. Redox

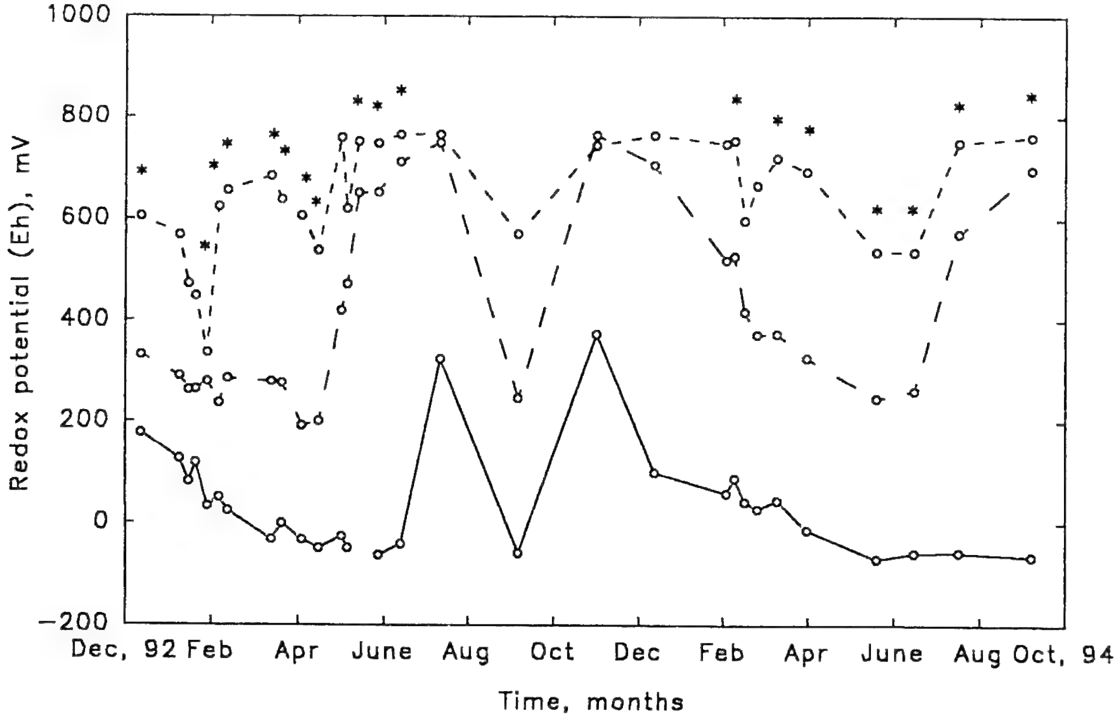

Figure 1. Mean redox potential at Site 1 (- - -), Site 2 (- –) and Site 3 (——) at the 15-cm depth from December 1992 until October 1994. Sampling dates on which there were statistically significant differences between sites are designated by an asterisk above the date.

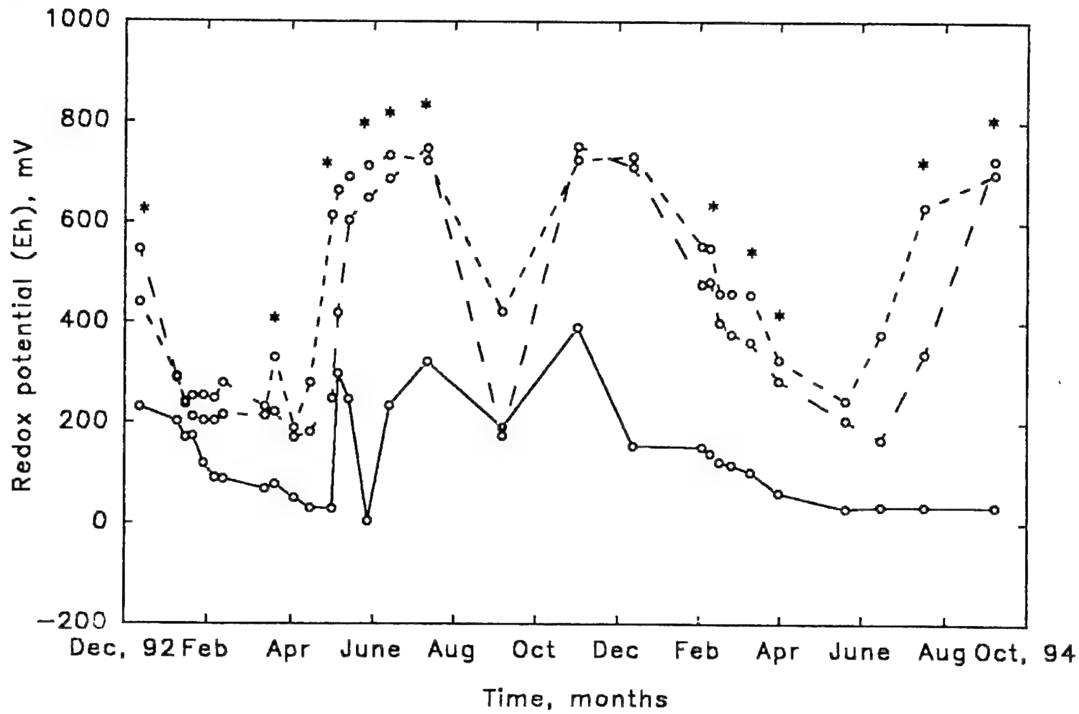

Figure 2. Mean redox potential at Site 1 (- - -), Site 2 (– -) and Site 3 (——) at the 30-cm depth from December 1992 until October 1994. Sampling dates on which there were statistically significant differences between sites are designated by an asterisk above the date.

potentials at Site 2 were intermediate to redox potentials observed at Site 1 and Site 3.

Seasonal trends in redox potential were most apparent at Site 2. Redox potentials were lower during the winter and spring months when the water table was shallower, and higher during the summer and fall months when the water table was deeper. Mean redox potentials at Site 2 were different from those at Site 1 only during the winter and spring months when the redox potential was the lowest. The large decrease in redox potentials observed in September,1993 was due to a heavy rainfall event the day previous to sampling. The heavy rainfall was indicated by drifted litter observed at Site 1 and water remaining in depressions at Site 2.

Redox potentials at the 30-cm depth in Site 1 and Site 2 were not statistically different during most of the study. Redox potentials at Site 1 and Site 2 were significantly different from those at Site 3 during periods when the soil wetness was changing in early summer and early spring. Mean redox potentials at the three sites were more similar at the 30-cm depth than the differences observed at the 15-cm depth (Figure 1 and 2). Redox potentials at the 30-cm depth in Sites 1 and 2 showed more seasonal variation than was observed in the same sites at the 15- cm depth.

Conclusion

Differences were observed among redox potentials at the three sites. The majority of significant differences in redox potential occurred between Site 1 and Site 3 at the 15-cm depth. Redox potentials at Site 2 were intermediate in measurement to the those at Sites 1 and 3 and displayed the largest amount of seasonal variation.

THE WESWAVES PROJECT: WAVE ACTION AND THE ERODIBILITY OF SALT MARSH SOILS

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Over 100 coastal wetland restoration projects affecting

thousands of acres are now in various stages of planning, design and construction in coastal Louisiana (Boesch et al. 1994), but few measurements have been made of waves and currents in the shallow marsh / channel / pond settings that are to be restored. Because this information is critical to the design and evaluation of the projects being constructed, CERC researchers with the Army Wetlands Research Program (WRP) joined with colleagues at LSU to augment an ongoing U.S. Geological Survey (USGS) study of marsh loss processes. The USGS effort began in 1988 and was recently completed (Roberts et al. 1994). WRP involvement led to development of a prototype instrument array (WESWAVES) that was used to acquire synoptic measurement of waves, suspended sediments and geotechnical parameters in representative stable and deteriorating salt marsh/pond sites in Louisiana's coastal delta plain.

Vertical accretion is widely understood to be the primary mechanism by which intertidal marshes maintain themselves against the apparent sea level rise (ASLR) caused by the combination of (1) global sea level change, (2) regional subsidence and (3) the net effect of local erosion, deposition and consolidation of the marsh surface. Analysis of aerial imagery from coastal Louisiana showed that conversion of wetlands to small ponds accounted for more than 70 percent of the land loss in three deltaic basins between 1955 and 1978, with the remainder more directly attributable to canal dredging and the retreat of Gulf of Mexico and bay shorelines (Leibowitz and Hill 1987).

Submergence, impoundment, grazing, burning, salinity stress and burial are among the factors that have been implicated in the initial formation of marsh ponds throughout the world. Rip-up, rolling and compression of poorly attached or floating marshes was observed to create new open water areas following passage of Hurricane Andrew in Louisiana. Otherwise, pond formation and expansion in firmly attached marshes does not appear to be explainable as a simple erosion process involving only the removal of sediment by waves or currents.

Our hypothesis was that pond expansion occurred when shear forces produced by waves and currents exceeded the shear strength of the marsh soil matrix. This could occur if forces associated with waves and currents were to increase significantly, or, alternatively, if the shear strength of the soil were to decrease by a similar proportion. We set out to examine these relationships in two representative salt marsh / pond complexes that were being monitored as part of the USGS project.

Experimental Approach

Although the ponds were about the same depth, marsh surface elevation at the OB site was estimated from water level time-series to be about 10 cm higher than at BC. The OB pond is a

stable landscape feature visible in 1940's photography, while the BC pond is of more recent origin and is in an area of rapid marsh break-up and loss. The OB pond did not enlarge or contract during five years of observation which included the passage of Hurricane Andrew. The BC pond margin retreated more than 2 m during the same period and, after the hurricane, opened up to the north to become an embayment of a larger water body, such that it was no longer isolated.

Winds were measured just above the elevation of the marsh grass and wave stress at the pond bed was estimated using pairs of pressure sensors fixed at the bottom that were separated by about 8 m. One sensor was placed in shallower water at the pond margin, while the other was positioned closer to the center of the pond in water that averaged 20 cm deeper. Autosamplers were deployed to collect water samples for suspended sediment analysis from the pond margin and from a marsh surface station located 20 m inland of the edge of vegetation. Sediment-erosion table (SET) stations were established to monitor changes as small as 0.3 cm in local soil surface elevation on the marsh surface and at unvegetated pond margin and bottom stations (Boumans and Day 1993). Eight cm diameter cores, 40 cm long were collected from the same locations. Cores were split and tested for fall cone (penetration) and vane shear strengths. They were then sectioned and analyzed for unit weight, bulk density and organic matter content.

Wave and Suspended Sediment Measurements

Synoptic wind, wave, water level and suspended sediment data were acquired in 1992, 1993 and 1994 from the BC pond on 13 days and at the OB pond on 15 other days for a total of 191 ensemble datasets. The highest wind speed recorded at 1 m was 5 $m\text{-}s^{-1}$. Total wave energy and frequency were extracted from spectra generated from each detrended pressure record to provide an analog of bed shear stress.

Despite the shallow depths of the ponds, the locally generated waves measured were so limited by the 50 m fetch that they were essentially deep water waves that did not impose significant stresses on the bed. The records were examined to see whether an intrusion of lower frequency and perhaps larger waves from outside the pond system occurred when the marsh surface was flooded, but no such intrusion was observed. After Hurricane Andrew, however, the BC pond opened up rapidly along the north side, as has been described. Then, waves with frequencies between 1 and 2 Hz were recorded and provided the highest energy conditions monitored with the bottom mounted sensors.

Total suspended sediment (TSS) concentrations in the ponds ranged from 10 to 200 $mg\text{-}l^{-1}$ at BC and from 20 to 400 $mg\text{-}l^{-1}$ at OB. Mean TSS concentration in the OB pond (107 $mg\text{-}l^{-1}$) was nearly twice that at BC (67 $mg\text{-}l^{-1}$) while values from the marsh surface were

similar (83 at BC, 88 at OB). If wave resuspension of sediments within the pond were the primary forcing for TSS concentrations within the pond, a negative correlation with depth would be expected. In fact, the reverse was observed. Water level and TSS data from the pond margin were significantly positively correlated for both the BC and OB sites suggesting that sediments in the pond water column primarily enter the ponds from the bayou via the inlet channel rather than through wave resuspension. TSS in the OB pond was also significantly negatively correlated with the percentage by weight of organic matter in the suspended sediment, indicating that most variation of TSS in the OB pond could be explained by the introduction of inorganic sediments from the bayou. Such a correlation was not significant in the BC pond which received less inorganic sediment from any source.

Soil Elevation, Composition, and Strength Measurements

SET measurements of local surface elevation changes resulting from deposition, erosion and consolidation in the upper 2 m of the sediment column showed a two year loss of 1 cm (+/- 0.3) in the elevation of the pond bottom at the BC site. Elevation at the pond margin dropped 2.8 cm at both sites. The passage of Hurricane Andrew did not alter the elevation trend of the pond margin or bottom. Marsh surface elevation showed no significant change at BC (-0.3 cm) but increased at OB by 1 cm over two years. These results indicate that the BC marsh is not aggrading at a sufficient rate to offset any regional ASLR greater than zero. The OB marsh, in contrast, appears to be building up its surface at a rate close to ASLR estimates for this area.

Saturated soil unit weights are higher at the OB site than at BC. The organic matter contribution to the wet weight was similar at both sites but samples from OB cores had more than twice the mineral matter content . Dry bulk densities at OB were also twice those at BC, averaging 4.0 (0.4 g-cm^{-3}) and 1.9 kN-m^{-3} (0.19 g-cm^{-3}), respectively. Fall cone penetration tests provided the most repeatable means of estimating cohesive shear strength as the soils were nearly liquid, particularly at BC. The shear strength of the vegetated marsh at the OB site (103 kN- m^{-2}) is two orders of magnitude higher than that at BC (1 kN-m^{-2}). An order of magnitude difference between the two sites was also found in cores from the unvegetated pond edge and bottom.

Discussion

The results of this work do not support the hypothesis that ponds of the median size (0.2 ha) expand through simple erosion due to waves. The wave regime at both sites was similar but pond response was quite different. Marsh and pond soils at the OB site had cohesive strengths that were greater than at BC by one to two orders of magnitude. Process data supplied by the WESWAVES array added an important element to the understanding of coastal marsh

loss that has emerged out of the USGS project (Roberts et al. 1994). Because the marsh at BC is lower, it is flooded for longer periods such that infrequent opportunities exist for drainage and consolidation. As waterlogging continues, plants are increasingly stressed, leading to lowered productivity and finally death. The formerly living root mass decomposes rapidly, reducing surface elevation further through a decrease in volume. But plant death also reduces soil strength so that marsh scarps become unstable and fail. Low-cost field methods for surveying in-situ soil strength in marsh soils can be developed that will provide a much needed technique for comparing various sites and assessing performance of restoration projects. While accurate vertical elevation control is difficult to obtain in isolated marshes, the SET technique provides a precise means to monitor elevation response.

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SESSION RE11

RESTORATION, PROTECTION, AND CREATION: GENERAL FRESHWATER WETLAND RESTORATION AND CREATION

Ms. Linda Winfield, Chair

HYDROLOGIC DESIGN AND RESTORATION PLAN FOR THE THREE FORKS MARSH CONSERVATION AREA

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The Three Forks Marsh Conservation Area (TFMCA) is part of a flood control and environmental restoration effort being undertaken jointly by the USACE and the St. Johns River Water Management District (SJRWMD) in Southcentral Florida. It encompasses about 14,000 acres of formerly drained St. Johns river floodplain (Figure 1). The restoration goal is to convert TFMCA to wetlands and to reconnect it hydrologically to the river.

Ground elevations in TFMCA are 2 to 3 feet lower than adjacent areas of the St. Johns Marsh Conservation Area (SJMCA) due to soil subsidence. Therefore, a levee which separates the TFMCA from the SJMCA must be maintained to prevent overdrainage of the SJMCA during dry periods. Hydrologic modeling was used to determine the size of inlet and outlet weirs that would regulate stage to create a natural hydrologic regime in both marshes. Hydrologic statistics used to define a natural hydrologic regime and set restoration goals are: mean depth, inundation frequency, minimum range of yearly fluctuation, timing of fluctuation, water level recession rates and minimum water levels (Miller et al., 1993). Hydrologic statistics are defined relative to a range of critical marsh elevations.

The Upper St. Johns Hydrologic Model (USJM) was used for this study (Suphunvorranop and Tai, 1982). An iterative process, comparing model results of a number of design options to the hydrologic criteria, was used to determine the best restoration plan.

Based on model results, inflows to the TFMCA will occur from the SJMCA over a 350 ft weir with a crest elevation of 19.5 ft NGVD (Figure 1). Downstream, a 600 ft weir with a crest elevation of 20 ft NGVD will discharge back into the SJMCA. A 250 cfs capacity culvert structure will also discharge from the TFMCA back into the SJMCA to create smooth transition to low flow condition when flows

over the weir stop.

Simulation runs (1942-1988) indicated that under the plan conditions, all environmental hydrologic criteria for the TFMCA would be met (Table 1). For SJMCA, all criteria will be satisfied except for the mean depth and its inundation frequency at river mile 277.06 (Figure 1). Criteria violation at this river mile can be attributed to rapid drainage through a canal located on the left bank.

Restoration of the TFMCA will establish approximately 7,000 acres of open water habitat in the northern part and 7,000 acres of freshwater marsh habitat in the southern half. After the structural components are built and the project is fully operational, the marsh stage will be monitored to verify if the environmental hydrologic criteria are being met.

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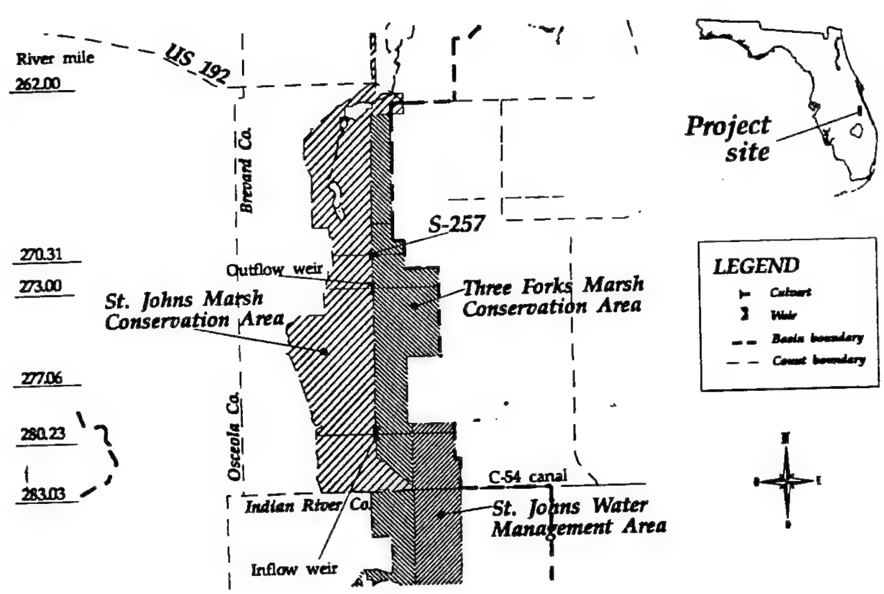

Figure 1. Three Forks Marsh Project Area.

Table 1. Criteria-related performance summary for the TFMCA

Criteria	Goal	Simulated
Mean Depth, ft	18.00	18.73
18.0 ft Inundation	60.0%	68.0%
17.5 ft 30 Day Exposure	50.0%	55.0%
Timing of Fluctuation	Seasonal	Met
Stage Recession Rates		
30 Day	< 1.2 ft	Met
7 Day	< 0.5 ft	Met
16.5 ft Duration	95%	97%

CREATING WETLANDS FROM FARM LAND IN CENTRAL FLORIDA

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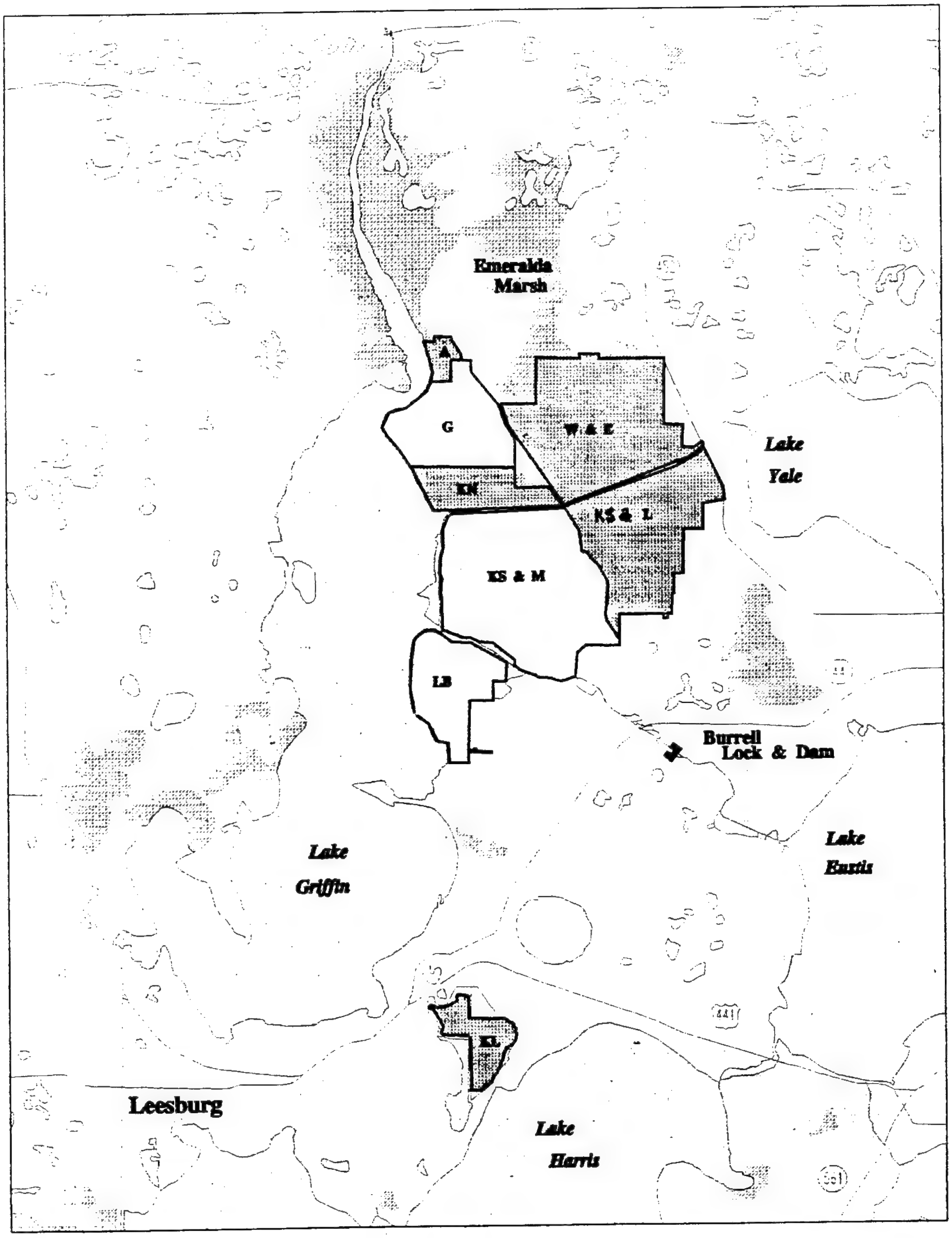
Abstract

Since 1991 the St. Johns River Water Management District has acquired about 8,000 acres of muck farms adjacent to the Ocklawaha River, Lake Griffin, and Lake Harris in Central Florida. Prior to agricultural development the area consisted primarily of shallow emergent marsh dominated by sawgrass interspersed with upland habitat. Water control and land clearing for farming was initiated in the early 1900s and extensive agricultural expansion occurred after World War 11. The muck farms were used to grow vegetables and to provide forage for cattle. Increased eutrophication of waters of the remaining wetlands, Lake Griffin, and minor creeks has occurred due to agricultural nutrient loading. Oxidation of the farmed peat soils resulted in substantial soil subsidence below the level of Lake Griffin. Creation of wetland and aquatic habitat, improvement of water quality, and provision of recreational use are the main goals of restoration and management of the conservation area.

Introduction

The Emeralda Marsh Conservation Area (EMCA) encompasses about 15,000 acres and is located northwest of Orlando in Marion and Lake Counties, Florida (Fig.1). About 8,000 acres are primarily former muck farms and ranches. The Florida Department of Environmental Protection (FDEP) was initially responsible for shared acquisition and management of the area through the Conservation and Recreation of Lands (CARL) program. The majority of the area under public

Figure 1. SJRWMD "Muck Farms"



☐ District "Muck" Farms Flooded or to be Flooded

☐ District "Muck" Farms in Lake Griffin Flow-way Projects

A = Ashley Farm
E = Eustis Muck Farm
G = Getford Farm
KL = S.N. Knight Leesburg
KN = S.N. Knight North
KS = S.N. Knight South
L = Long Farm
LB = Lowrie Brown Farm
M = Mathews Farm
W = Walker Ranch

ownership is managed by the St. Johns River Water Management District (SJRWMD). Funding for restoration and management is provided primarily through the Surface Water Improvement and Management (SWIM) Act authorized in 1987.

The primary management goals for the area are 1) to restore the hydrological and ecological functions of the Ocklawaha River floodplain, which includes the purchased properties; and 2) to reduce agricultural discharge to Lake Griffin and Ocklawaha River Basin (SJRWMD, 1992). The secondary goals are 1) protect and maintain wildlife habitat; and 2) provide public access for recreational and educational uses of the properties.

Description of the Area

The EMCA consists of two management areas that includes muck farms purchased by the District since 1991. The primary management area consists of eight farms located in the floodplain of Lake Griffin in the Ocklawaha Chain of Lakes. The secondary management area consists of a single farm located adjacent to Lake Harris.

During the mid to late 1800s steamboat transportation along the Ocklawaha River initiated agricultural development along the shores of Lake Griffin (SJRWMD, 1988). By the late 1940s extensive agricultural expansion occurred. Through diking and drainage efforts large muck farms ranging from 100 to 2000 acres replaced sawgrass and wet prairie communities. Burning the marsh vegetation was a common practice used to prepare the farms for vegetable production and cattle grazing. The muck soils underwent oxidation and compaction, with a subsequent loss of porosity and water holding capacity (Kushlan, 1992). During the interim between property acquisition and restoration, farming operations have been discontinued.

Restoration Plans

Restoration of the EMCA involves the re-establishment of the floodplain ecosystem. Due to altered hydrology, soils, and nutrient input the wetland and aquatic ecosystems of the EMCA may not return to pre-agricultural conditions. The area, however, may be restored to provide improved habitat for fish and wildlife. Hydrological conditions will be dictated by regulation of lake levels. Existing water control structure determine flow to Lake Griffin to prevent flooding and/or provide water storage for navigation and recreation. The water depths and fluctuation have been dampened, resulting in large areas of the EMCA with permanent inundation.

Six management units have been defined in the EMCA based on topographical elevations, artificial boundaries (ie. roads), hydrological connectivity, and primary function. One or two units will be wetlands used primarily for water quality improvement.

Other units will provide aquatic, wetlands and some upland habitat.

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WETLAND RESTORATION TO BENEFIT ENDANGERED FISH HABITAT IN THE UPPER COLORADO RIVER BASIN

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The Colorado River Endangered Fish Recovery Implementation Program is a cooperative, 15-year program of Federal and State agencies, environmental organizations and water development interests aimed at re-establishing self-sustaining populations of endangered Colorado River fish while providing for new water development.

The Recovery Program has five major elements: (1) habitat management through provision of instream flows, (2) habitat development and maintenance through nonflow alternatives, (3) stocking of native fishes, (4) management of non-native species and impacts of sport fishing, and (5) research, monitoring, and data management.

Four native fish species that inhabit the Colorado River Basin are federally listed as endangered: Colorado squawfish, humpback chub, bonytail chub, and razorback sucker (razorback). Each of these four species was once abundant in the Upper Basin; however, they have declined in numbers and are now threatened with extinction from their natural habitat.

Factors accounting for the current status of these species include direct loss of habitat, changes in water flow and temperature regimes, blockage of migration routes, and interactions with introduced (non-native) fish species.

The Floodplain Habitat Restoration Program is a major element

of the Recovery Program and is the focus of this paper. The purpose of the Floodplain Habitat Restoration Program is to restore floodplain habitats to assist in recovery of razorback suckers (Xyrauchen texanus), based on the assumption that razorback require floodplain habitats to complete their life cycle.

Historically, razorbacks were abundant and widely distributed in the Colorado River. Most razorbacks captured in recent years in the Green, Colorado, and Yampa Rivers are thought to be more than 20 years old and there is little to no recruitment of young fish into the adult population.

Literature review and field observations indicated that extensive habitat alteration of the Colorado River system occurred due to the timing of several major events. A period of extensive erosion coincided with the invasion of tamarisk (salt cedar) in the early 1900,s and has reduced channel widths by an average of 27% at Canyonlands (Graf, 1978). This was followed by sediment supply reductions in the 1940's as river banks stabilized during alternating climatic cycles and changing land use practices. Subsequent construction of large storage reservoirs in the 1960's reduced both peak discharge and sediment. This sequence of events has resulted in the almost total elimination of habitat for larval razorback.

On the Green River, optimum razorback spawning conditions appear to occurs on the rising limb of the hydrograph about 7 to 10 days before peak flows (Tyus and Karp, 1990). Reduced peak flows as a result of Flaming Gorge Dam combined with channelization by levee construction and other channel morphology changes, have resulted in lack of access to floodplain nursery habitat for both razorback larvae and adults.

The seasonal abundance of zooplankton is also an important food resource for razorback and explains their attraction to flooded bottomland areas. Studies have found that zooplankton concentrations are 14.5 times grater in backwaters and are significantly higher in flooded bottomland habitats.

The mission of the flooded bottomland program was to inventory the flood plain to provide candidate sites for acquisition, restoration and management. The Recovery Program in 1992 began a massive program to identify and restore selected flooded bottomland habitats, with the focus on improving razorback recruitment. The first site selected for restoration was Old Charlie Wash wetland, located on the Ouray National Wildlife Refuge near Ouray, Utah. The wetland had previously been diked off from the river and used as migratory bird habitat. To open up the wetland an alternative outlet/fish passage structure was designed and installed. The structure included stoplogs a fish trap and a rotary fish screen to exclude non-natives.

During 1993, five sites were identified and restoration plans were developed of each site. During 1994 a team of biologists identified all potential sites available on the Colorado and Green River Systems. The biologists used tools such as air photography, aerial videography and oblique 35 mm slide taken during the high flows of 1993 to identify and screen sites. In total, 20 sites were identified and selected for further evaluation. Each site was then visited by screening teams to evaluate each site for contaminates, biological diversity and flood frequency. Conceptual development plans are currently being developed for several high priority sites.

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MITIGATION IN DETENTION BASINS IN HARRIS COUNTY, TEXAS

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Harris County Flood Control District (HCDCD) is creating approximately 20 acres of wetlands and bottomland hardwood forest within stormwater detention basins at two separate project locations. This effort was required by the Department of Army Permits for wetland losses during construction of channel improvements, stormwater detention basins, and a levee. These projects were necessary to control water flow in the channels and to reduce flooding of adjacent homes and businesses.

The Inverness Forest mitigation plan consists of 4.1 acres within three excavated detention basins, including five emergent marshes. In the spring of 1994, a total of 728 15-gallon trees, and 703 5-gallon shrubs were planted on 15-foot centers. The basins are being monitored three times per year for two years to assess the physical condition of the plants and note any required maintenance or replacement needs. According to the permit, a minimal success criteria of 80 percent survival of healthy and

TABLE 1: Summary of current survival rate of trees and shrubs at Inverness Forest and White Oak Bayou mitigation sites.

	Inverness Forest		White Oak Bayou	
Plant Species	Total Quantity	Current Survival Rate (%)	Total Quantity	Current Survival Rate (%)
Cephalanthus occidentalis L.	222	98	NA	NA
Myrica penssylvanica Lois.	94	99	NA	NA
Symphoricarpos orbiculatus Moench	61	71	NA	NA
Halesia diptera J. Ellis	84	56	NA	NA
Callicarpa americana L.	95	93	NA	NA
Rhus copallina L.	48	46	NA	NA
Craetagus spathulata Michx.	99	91	NA	NA
Total Shrubs	**703**	**86**	NA	NA
Taxodium distichum (L.) L.C. Rich.	25	92	298	NA
Carya aquatica (Michx. F.) Nutt.	48	98	302	NA
Fraxinus caroliniana Mill.	46	100	NA	NA
Quercus lyrata Walter	46	100	289	99
Nyssa sylvatica Marshall	46	63	NA	NA
Quercus michauxii Nutt.	39	100	648	96
Betula nigra L.	43	95	680	90
Quercus nigra L.	60	100	464	93
Acer rubrum L.	56	57	NA	NA
Celtis laevigata Willd.	39	0	NA	NA
Liquidambar styraciflua L.	77	52	NA	NA
Quercus shumardii Buckley	75	80	NA	NA
Cornus drummondii C.A. Meyer	37	16	NA	NA
Morus rubra L.	50	98	NA	NA
Juniperus virginiana L.	41	81	NA	NA
Quercus phellos L.	NA	NA	670	90
Quercus nuttallii Palmer	NA	NA	653	98
Quercus alba L.	NA	NA	953	88
Total Trees	**728**	**76%**	**4957**	**93**
TOTAL	**1,431**	**81%**	**4957**	**93**

thriving plants needs to be achieved by the end of the second growing season. The contractor is required to sustain a 100 percent survivability rate during the maintenance period. Considering all three basins collectively, an 82 percent survival rate has been achieved after the first growing season (Table 1). However, only 48 percent of the plants were observed to be in a healthy and thriving condition.

The White Oak Bayou mitigation plan consists of a 12.7-acre excavated basin and an emergent marsh. In February 1994 a total of 4957 1-gallon trees were planted on a 10-foot centers. To comply with the Department of the Army Permits, at the conclusion of the three year maintenance period the mitigation area must have an average density of 400 trees per acre (92% survival) with a minimal plant height of two (2) meters (6.5 feet). After eight months the survival rate achieved in the basin is 93 percent, which meets the minimum 92 percent survival rate specified in the permit, however, only 79 percent or 3983 of the 5030 plants were observed to be in a healthy condition (Table 1).

Primary causes of mortality may be lack of water and/or slope erosion. Other potential causes of mortality may be insect or fungal infestations or the inadvertent basal bark damage incurred during routine maintenance mowing and weed control, which could allow insect and/or fungal disease. The slope erosion is being corrected, the dead plants will be replanted and care will be taken for the damaged ones.

On some monitoring days, no wildlife was observed because of mowing activities in the basins. Disturbance from human movement and equipment noise likely disrupted any normal wildlife use. However, the following species were observed: Northern mockingbird (Minus polyglottos), common grackle (Quiscalus quiscula), mallard (Anas platyrhynchos), mourning dove (Zenaida macroura), great blue heron (Ardea herodias), yellow-crowned night-heron (Nyctanassa violacea), great egret (Casmerodius albus), snowy egret (Egretta thula), Southern leopard frog (Rana sphenocephala), and mud turtle (Kinosternon flavescens flavescens). Wildlife utilization is anticipated to increase as the shrubs and trees continue to grow, providing more food resources, concealment cover, and substrate for nesting.

PHYSICAL EFFECTS OF NAVIGATION ON WETLANDS

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The primary physical effect of navigation on wetlands results from wave activity but other effects, such as water level drawdown, return flows, propellor jet effects, and sediment resuspension, can be significant. Physical effects as discussed herein refer to changes in the elevation and speed of the water as a result of vessel movement. Factors such as fuel spills and waste dumpage are not addressed herein.

Vessels can be broadly classified as confined when the cross-sectional area of the vessel takes up a significant part (defined as greater than 2-5 percent) of the cross sectional area of the waterway in which they are traveling and unconfined for vessels that are not significant relative to the waterway area. While the effects described herein apply to all waterways, specific examples are given for the Gulf Intracoastal Waterway (GIWW).

Confined Vessels: An example of a confined vessel on the GIWW is barge traffic whose cross sectional area can be 1/6 of the cross sectional area. The primary physical effects (Figure 1) of a confined vessel are water level drawdown, slope supply flow, transverse stern waves, return flows, propellor jet effects, and sediment resuspension. Because of their relatively slow speeds, short period wave activity is generally low. Drawdown and return velocity persist during passage of the barge which can be up to two minutes on the GIWW. Return velocity and drawdown magnitudes on the GIWW are up 0,52 m/sec and 0.21 m, respectively based on measurements by Zhang et al (1993). Drawdown over a two minute span can temporarily move water from- adjacent areas toward the main channel. This flushing action may be beneficial in some cases. In many areas, the water that returns to the adjacent areas may have a higher sediment concentration. Drawdown of shallow near shore zones can result in removal of water off of the nearshore slope. This often leaves the adjacent bank in a geotechnically unstable condition. Refilling of this zone after barge passage (slope supply flow) often results in a transverse stern wave which moves along the bank at the vessel speed and appears as a turbulent bore which can erode and suspend sediments.

Unconfined Vessels: Examples of unconfined vessels on the GIWW are recreational boats and commercial shrimp boats. Smaller recreational boats, because they have sufficient power and hull form to achieve a planing attitude, often have an intermediate speed which results in maximum wave height generation. This intermediate speed is generally not the speed at which small recreational boats traverse waterways. Other unconfined vessels which can not achieve a planing attitude, tend to show an increase in wave height with increase in vessel speed. These vessels can cause significant short period wave activity. Zhang et al (1993) measured maximum wave heights of 0.5 m from shrimp boats along the GIWW. Short period waves can resuspend sediments in near shore areas and in shallow water away from shorelines. Short period waves may break directly on the edge of the wetland. If the water level

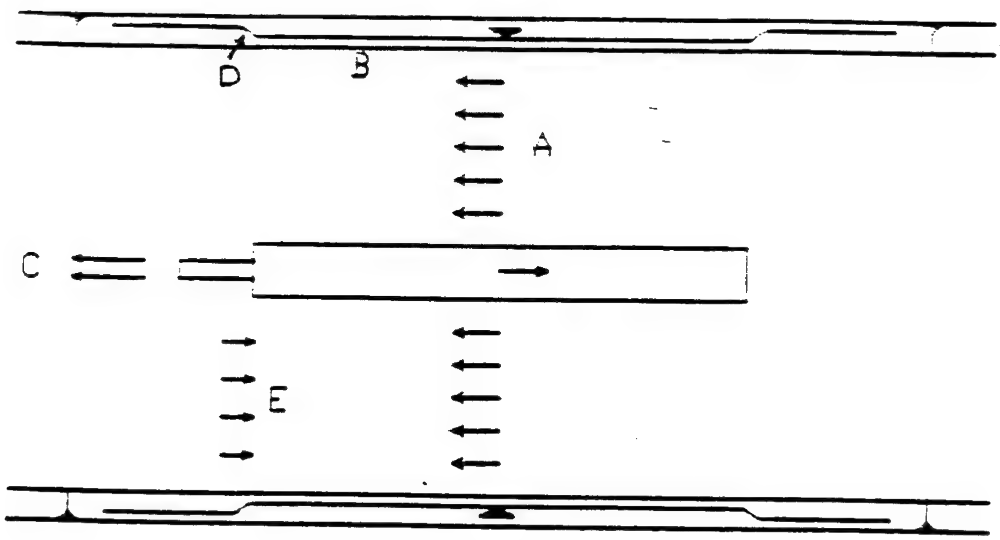

Figure 1. Navigation Effects for Confined Vessels. A is the return velocity, B is drawdown, C is the proepllor jet, D is the transverse stern wave, and E is the slope supply flow.

is low enough, the wetland vegetation may be undermined by erosion depending on soil characteristics and frequency of occurrence.

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SESSION RE12

RESTORATION, PROTECTION, AND CREATION: WETLAND RESTORATION IN COASTAL LOUISIANA AND TEXAS

Dr. Conrad J. Kirby, Chair

VEGETATIVE RESPONSES TO IMPLEMENTATION OF CAMERON-CREOLE IN SOUTHWESTERN LOUISIANA, AN ECOSYSTEM-BASED WATERSHED PROJECT

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The Cameron-Creole Watershed Project incorporates approximately 113,000 acres in Cameron Parish, Louisiana where saltwater intrusion was converting the marsh to open water by killing the vegetation that held the soil in place (SCS 1983). To counter this conversion a cooperative watershed protection project was established for Cameron-Creole through support of local sponsors (SCS 1967).

An ecosystem based planning approach was used to address concerns of the diverse user groups and restore the area to a healthy marsh. To appease estuarine fisheries interests a two-year study was conducted involving paired ponds within the watershed. Study results led to structural design adjustments that allowed for marine organism access.

The major structure at Grand Bayou has four 8-foot wide gated bays set at 4 feet below water level and is designed to also allow access of fishermen through a 10-foot wide boat bay. The structures at Lambert and Peconi Bayous have gated bays set at 4 feet below water level with vertical slots to allow ingress/egress of marine organisms. The structures at Mangrove and Noname Bayous have bays set on fixed-crest weirs with one of the weirs on each structure having vertical slots allowing ingress/egress. In addition to the five main structures, culverts and stoplog structures were installed under La. Hwy. 27 on the eastern edge of the project, and flapgated culverts installed to the north on the Intracoastal Waterway. These structures permit inflow of freshwater to offset salinity intrusion.

The actual operation of the structures are conducted by US Fish and Wildlife Service personnel at Cameron Prairie National Wildlife Refuge. Operation goals are to maintain the 5ppt and 12ppt

isohaline lines at 1972 levels within the project.

Baseline data was collected in 1972 involving the mapping of soils and vegetation. To determine structure and operation effectiveness the NRCS is monitoring changes in the vegetative communities. Monitoring is conducted with transects at five year intervals beginning in 1983.

These surveys involved use of a helicopter for transporting two teams of scientists in a leapfrog manner along predetermined sample sites. The 147 sample sites, spaced approximately one mile apart, are plotted on aerial photographs to provide continuity. Sampling entails the determination of the plant species that occurs at each one foot interval along a 100 foot transect line.

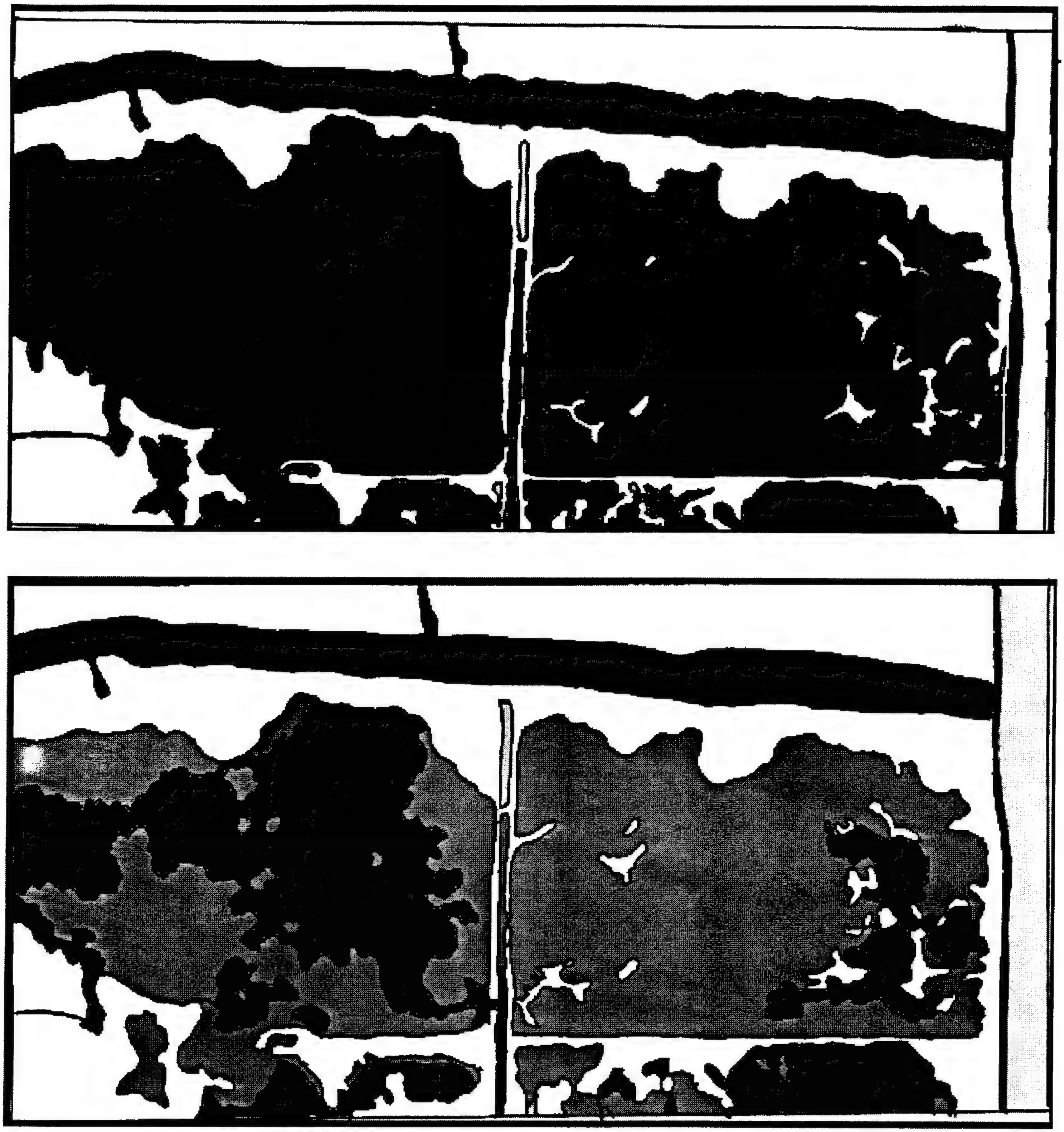
Land and water were digitized from aerial photography taken in 1953, 1978, 1990 and 1993 (Table 1). A digital database will be overlaid with generalized vegetative maps (USFWS 1951; Chabreck, Joanen & Palmisano 1968; SCS 1993) for comparison purposes. A report is currently being written that examines these changes.

TABLE 1

CAMERON-CREOLE WS (Preliminary GIS* Data)

YEAR	LAND	WATER
1953	109,201 ac. (96.95%)	3,441 ac. (3.05%)
1978	95,411 ac. (84.70%)	17,231 ac. (15.30%)
1990	90,158 ac. (80.04%)	22,484 ac. (19.96%)
1993	93,868 ac. (83.33%)	18,774 ac. (16.67%)

* Base Source: USDA-SCS Digital SSURGO data, USGS 7.5' Mylar Base Quads, Universal Transverse Mercator Projection; Ellipsoid - Clarke66.



The area adjacent to Gibbstown Bridge and Blind have each experienced rapid growth of aquatic vegetation and increased emergent growth between 1990 (top) and 1993 (bottom).

Figure 1.

Infrared aerial photography shows dramatic improvement in the fresher reaches of the project. The area adjacent to the Gibbstown Bridge (Figure 1) experienced rapid growth of aquatic and emergent vegetation between 1990 and 1993. The project has returned this area to a low energy system that enhances vegetative growth. The ability to protect the area from saltwater surges and tidal scouring has been possible with structural operation. Continued benefits are expected with the project in full operation.

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STATUS REPORT ON THE CREVASSE PROGRAM AT DELTA NATIONAL WILDLIFE REFUGE

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Since 1983 the U.S. Fish and Wildlife Service has been actively involved in the construction of crevasses on Delta National Wildlife Refuge (refuge). These crevasses have resulted in the creation of hundreds of acres of emergent marsh, mud flats and shallow water areas. In an effort to quantify the impact of these crevasses on the natural resources of the area a number of management studies have been initiated over the past 3 years. Results from these studies are still preliminary but crevasses

appear to provide positive benefits for a wide range of species.

Land forming the Delta National Wildlife Refuge is a product of sedimentation which originated when a breach known as Cubits Gap occurred in the natural levee of the Mississippi River. The breach or crevasse carried up to 60 million tons of sediment into Bay Rhondo. The result was a rapid filling of the bay, forming a large deltaic splay. The splay created by the crevasse encompassed approximately 100,000 acres of the former Bay Rhondo. Up until the hurricane of 1965, the marsh remained relatively stable. Large expanses of floton or floating marsh covered much of the area and supported a diversity of plant and animal species. The hurricanes of 1965 and 1969 devastated the floton marsh, picking up large mats and rolling the marsh inland. Artificial levees began to line the banks of the Mississippi River to control overbank flooding, and channelization of the river to permit access for large ocean vessels began. The natural processes of sedimentation were hampered, with the river now dumping most of its load into the deep waters of the gulf. These man-made changes, coupled with subsidence, converted approximately 51% of the freshwater marshes in the active delta to open water from 1956 to 1978.

Although reduced, a substantial volume of sediment was still carried from Cubits Gap to gulf waters by three main passes through the refuge. The natural levees of the passes prevented most overbank flooding until 1978, when several natural breaks (crevasses) occurred along Main, Brant, and Octave Pass. During the late winter and spring, floodwaters poured through the crevasses and deposited the sediments in the open water ponds, This resulted in the development of several splays. These subaerial splays quickly became vegetated and the majority of the wintering waterfowl using the refuge quickly began using the splays for feeding and resting areas.

In an attempt to duplicate these natural successes a man-made crevasse was dug through the south bank of Octave Pass in September 1983. The results were rewarding, and since that time 17 additional crevasses have been constructed. These deltaic splays accrete sufficiently to produce emergent vegetation in just a few years.

Attempts to quantify the effects of these splays have resulted in a number of management studies being initiated over the past three years. Such studies include soil fertility, waterfowl use of splay compared to non-splay areas, use of splays by migrating and overwintering shorebirds, fish assemblage characteristics of splays, and habitat use by wading birds. Results of these studies are preliminary but encouraging. Soil samples collected from ten developing splays in areas classified as fresh marsh (Chabreck 1972) were classified as very fine sandy loam, fine sandy loam, silt loam, and silty clay loam. Compared to the findings of Brupbacher (1973), levels of phosphorus and calcium were well above average, sodium and magnesium were below average,

and potassium was only slightly below average. Levels of all chemicals listed were above those recorded by Chabreck (1972) for this same area with the exception of magnesium which was below that recorded by Chabreck. Average pH was 7.62 and average percent organic matter was 1.58.

Developing splays provide suitable habitat for a wide range of shorebirds and wading birds while non-splay areas are usually of sufficient depth to preclude use by most birds in these groups. Construction of crevasses appears to have little effect on fish assemblages (preliminary data). Waterfowl use was compared for recently constructed crevasses and established splay areas of comparable size. Over the past three seasons waterfowl use on the recently constructed areas has averaged Beven (7) percent of birds using the refuge while use on the established splays has averaged 23 percent. Overall, an average of 80 - 90 percent of the waterfowl found on the refuge occur on established splays.

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SEDIMENT AND VEGETATION CHARACTERISTICS OF SIMILAR-AGED CREATED AND NATURAL WETLANDS IN THE LOUISIANA ATCHAFALAYA DELTA

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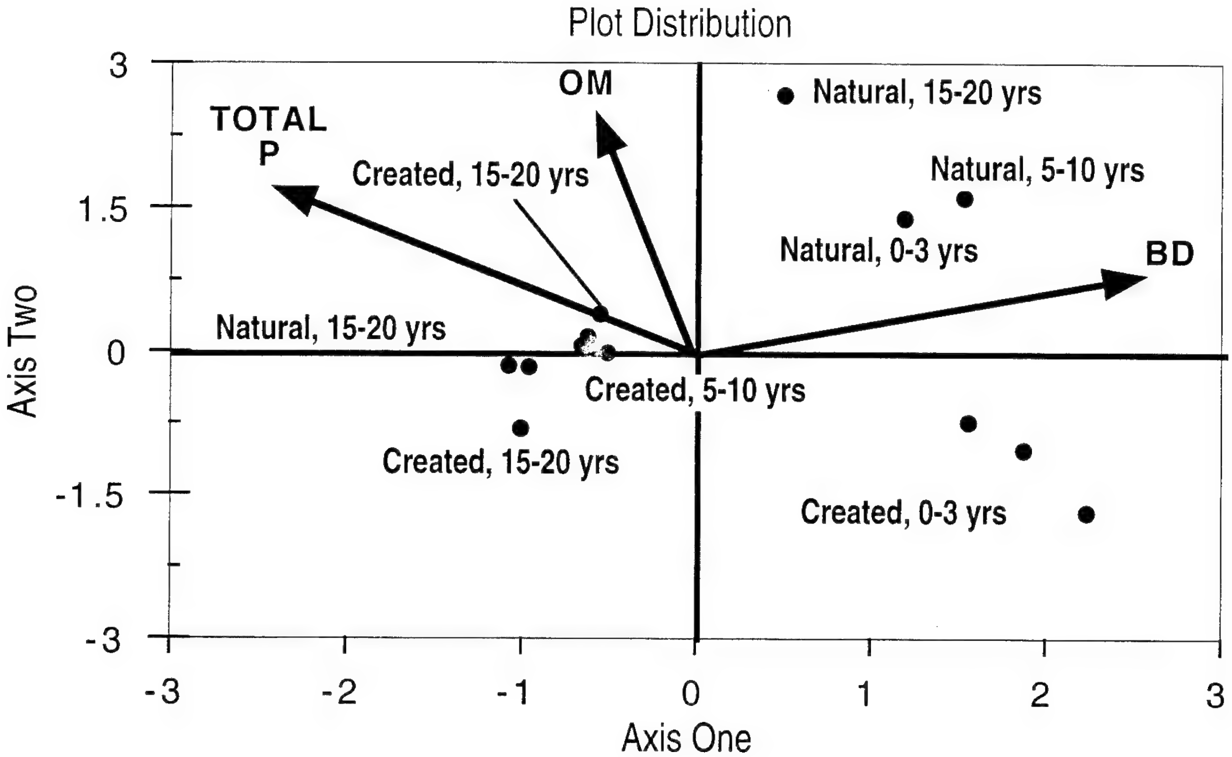
Created wetlands are used to mitigate losses of natural wetlands, however, there are limited data documenting the functional attributes and long-term development of these systems. Indeed, there is currently much debate over the appropriate measures of successful wetland creation. Quantitative data directly relating wetland structure (vegetation, soils) to



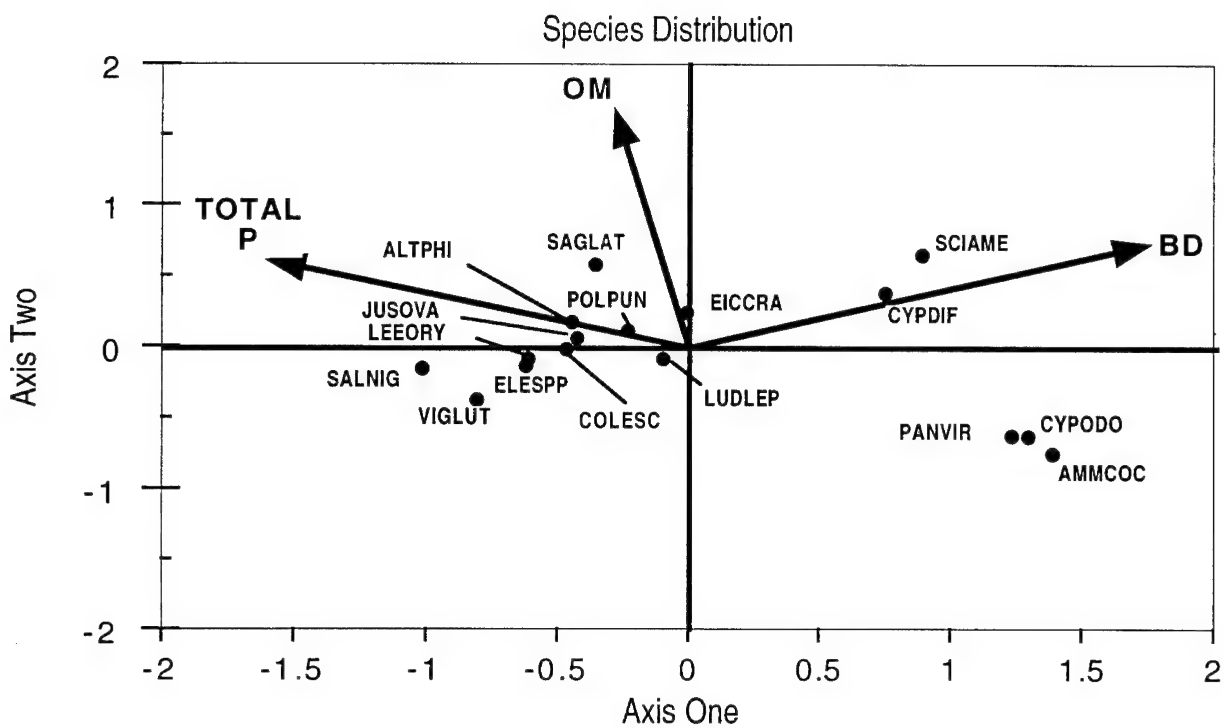


Figure 1. Canonical correspondence ordination diagram of created and natural wetlands of the Atchafalya Delta.

functions (redox reactions, nutrient cycling) in both natural and created wetlands is also urgently needed.

A unique feature of the Atchafalaya Delta in southwestern Louisiana is the availability of naturally created wetlands in the Atchafalaya Delta as appropriately aged analogs for wetlands created through dredge disposal operations. Our objective was to quantify structural and functional changes in both created and natural wetlands through time. Natural and created wetlands were selected within each of the following age groups: 0-3, 5-10, and 15-20 years old. Distinct elevational and vegetational zones were observed on many of the selected wetlands. These areas were separated into low, mid, and high elevation strata. Three permanent plots were randomly established in each strata. Samples were collected from the upper 10 cm of sediment with a hand corer from each plot in October of 1993, and January, May, and July of 1994. These samples were analyzed for bulk density, particle size, total N, total C, N03, NH4, available P, pH, and organic matter using standard techniques. Species composition and percent cover of each species were recorded in August and September of 1993 in 1.0 m-2 plots adjacent to the permanent soil plots.

There were few differences between natural and created marshes for any of the soil parameters measured. Generally, created wetlands in the 0-3 yr age group had lower sediment nutrient concentrations and organic matter than their naturally created analogs, however, these differences disappeared after 5 years. These differences are graphically illustrated by the ordination diagram produced through canonical correspondence analysis (Fig. 1). The dominant environmental gradients were bulk density (BD), organic matter (OM), and total phosphorus (Total P) (Fig. 1).

Vegetative cover showed no differences between natural and created marshes of similar age and elevation. Differences in species composition between natural and created islands as well as young and old wetlands were found. The 0-3 year old created wetlands had distinctly different species composition than the other wetland types (Fig. 1).

FISHERY UTILIZATION OF ESTABLISHED/RESTORED WETLANDS

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Coastal wetlands are a critical habitat for many important fishery species and the fauna on which they prey. Although casual use of restored and established marshes by such species has been reported, many details, particularly such things as the temporal development of faunal utilization have yet to be examined in detail. As part of the U.S. Army Corps of Engineers Wetlands Research Program, fisheries communities of established and restored marshes were examined at 4 locations on the Atlantic, Pacific and Gulf Coasts of the US. This paper, reporting results for 3 of the sites, represents the collaborative effort of numerous wetland scientists working under contract to the Waterways Experiment Station.

Winyah Bay, SC, Studies

Charleston District placed material dredged from channel maintenance in Winyah Bay to establish a 35-hectare salt marsh. As annual placement was done in spatially discrete areas, the marsh is a mosaic of variously-aged components built in increments of from 0.3 to 8.5 hectares.

In one study, both vegetation and the benthic macro-infaunal community were compared between different-aged marsh areas (about 5, 12 and 16 yrs) to observe species composition and successional changes. The vegetation and infauna were generally similar to those found in nearby natural marshes. With increasingly old sites, the infaunal community reflects vegetation changes, and concomitant changes in substrate physical conditions.

A second study focused on use by fishes and motile macroinvertebrates. The experimental design centered around lift net collections at varying distances from the marsh edge and depth of tidal flooding. The taxonomic composition and relative

abundance of the migratory fauna was consistent for similar marsh sites.

Beaufort, NC, Studies

Three dredged material islands in different watersheds were recontoured to identical experimental layouts to examine fish, shrimp and crab utilization of established salt marshes and interaction with adjacent seagrass beds. Animals began to utilize the planted saltmarsh and seagrass beds soon after they were installed. Abundances quickly (<2 yrs) reached that of natural marshes. Faunal densities in the seagrass beds, in contrast, did not resemble those of nearby, natural populations. Further, no linkage between seagrass and saltmarsh utilization was apparent for most species.

Galveston Bay, TX, Studies

Adjacent marshes of varying age (9, 5 and <1 yr) along the Gulf Intracoastal Waterway were examined for faunal utilization. Densities of small fishes, crustaceans and mollusks were measured within the vegetation at two elevations in each marsh using a drop sampler. Four months following planting of the youngest marsh, densities of most organisms were significantly lower compared with the two older marshes and a subsequent sampling 1 yr after planting. In comparisons of the two older sites to nearby natural marshes, there was no significant difference between densities for total fish or total crustaceans with the exception of the blue crab *Callinectes sapidus* which were found in lower abundance in the established marshes in fall samplings. However, in spring samplings, while fish densities were similar; crustaceans were significantly lower in the created marshes which supported only about 1/3 that of natural marshes.

PERFORMANCE OF EROSION CONTROL MEASURES FOR COASTAL WETLAND RESTORATION AND CREATION PROJECTS

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The U.S. Army Corps of Engineer District, Galveston (SWG) constructed three wetland restoration and creation projects using dredged material removed from the adjacent Gulf Intracoastal Waterway (GIWW). The projects provide habit for wildlife and aquatic organisms, and also provide erosion protection for nearby shorelines. Since the wetlands themselves are therefore exposed to

erosive forces, erosion protection was designed for their shorelines. The projects provided an opportunity to evaluate techniques for protecting newly placed wetland soils and vegetation.

Three projects are mentioned here. The first wetland restoration project is located in West Bay near Galveston, TX. (The pre-construction design was described in McCormick, Davis, and McLellan, 1992.) A 5000 ft long wetland island was constructed parallel to and south of the GIWW. The island was approximately 225 ft wide providing 20-25 acres. Several treatments were used to protect the dikes of the island including mild slopes (1V:10H and 1V:15H), coconut fiber mats, fiber mats with sprigged vegetation, a dynamic revetment, and a low-crested, offshore, geotextile tube. Site inspections indicated that the milder 1:15 dike side slope was more stable than the 1:10 slope. Most of the coconut fiber mats were destroyed within the first few months. After 2 years, the geotextile tube was undamaged and functioning well. While the dike behind the tube had suffered some erosion, the area was quiescent enough to allow the colonization of Spartina alterniflora. The dynamic revetment is made of small rocks allowed to move under wave forces to an equilibrium position. The revetment is at the tip of the island facing the east from which the largest waves tend to approach. The revetment was damaged during the monitoring period, but is still providing protection benefits. While the island has been modified by the wave climate, wetland vegetation has colonized many areas creating a somewhat random and appealing appearance. The island has also provided the benefit of protecting the shoreline across the GIWW from continued erosion. In this case, the protection has prevented the higher salinity bay waters from breaching the shoreline into the otherwise brackish marsh of Halls Lake.

Another wetland area was constructed by SWG adjacent to False Live Oak Island along the GIWW near the Aransas National Wildlife Refuge (ANWR), TX. The wetland was created from dredged material and a low-crested, rubble-mound breakwater was constructed offshore from the wetland to dissipate erosive wave energy. After one and a half years, the breakwater was unchanged and had provided complete protection for the newly established wetland. Portions of the wetland were planted with Spartina alterniflora and Spartina patens, but the overall vegetative cover is sparse.

The third project was constructed a few miles west of the False Live Oak Island projects adjacent to Ayers Island along the GIWW. The confinement dike for the new wetland was constructed from geotextile tubes which also provide erosion protection. After less than two years of monitoring, the tubes (and wetlands) were undamaged and functioning properly and vegetation was beginning to establish itself. Monitoring of the projects near the ANWR will continue.

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SESSION CW2

CONSTRUCTED WETLANDS:
NITROGEN AND PHOSPHORUS REMOVAL EFFICENCIES

Tommy E. Myers, Chair

THE RESPONSE OF A FRESHWATER WETLAND TO LONG-TERM LOW-LEVEL NUTRIENT LOADS

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Total phosphorus (TP) and total nitrogen (TN) mass balance calculations were calculated for Boney marsh, a subtropical constructed freshwater wetland located along the floodplain of the Kissimmee River in South Florida. River water (TP = 0.07 and TN = 1.70 mg/L) was diverted through the marsh for a nine year period (1978-1986). Rainfall contributed 7% and 3& of the total TP and TN budget, respectively, while pumped river water provided the balance of TP and TN supplied to the marsh. Monthly mean nutrient retention rates were 0.03 and 0.41 gm/sqm/month for TP and TN respectively. Nutrient retention was influenced primarily by nutrient loading rates.

Boney Marsh mean annual TP removal efficiency of 72% was comparable to nutrient removal efficiency data from other wetland treatment systems. Total phosphorus removal efficiencies were consistently higher than TN removal efficiencies at all times, and remained relatively unchanged during the entire study period. Unlike wetlands at temperate latitudes, Boney Marsh was a net positive sink for TP year-round but not for TN.

Studies of most constructed wetlands to date have been limited to studying short-term nutrient removal. The Boney Marsh data allowed us to investigate the marsh "aging" process. Cumulative mass retained and mass loading was consistent, as was nutrient retention rates during the study period. In addition, there was no decline in mass export and water volume flowing into and out of the marsh during the study period. Boney Marsh nutrient assimilation capacity remained high and invariable for the period of record for TP but not for TN.

Our analysis showed that studies which derive nutrient removal estimates from reductions in surface water concentrations alone may under-represent mass retention by as much as 5-% and 100%

for TP and TN, respectively.

Removal of nutrients by wetlands can be modeled as a first-order process, where the net settling velocity is governed by nutrient concentration and a settling rate coefficient (K). Total phosphorus settling rate derived from Boney Marsh data (9.93 m/yr) was consistent with reported literature values and in good agreement with the estimated long-term value for WCA-2A. Properly managed wetlands, through careful selection of inflow loading rate, can be very effective at removing nutrients from inflowing water for an extended period of time.

CONSTRUCTED WETLANDS FOR LIVESTOCK WASTE MANAGEMENT

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Introduction

Increasingly, the call is being made to make agriculture more compatible with environmental concerns. Presently, agricultural practices account for the largest single contribution to non-point source pollution. Run-off from cropland, pastures, feedlots, and farmsteads continues to add substantial inputs of nitrogen and phosphorus to the nation's waterways and groundwater. However, the agricultural community has been responsible for many of the advances in pollution abatement that already have been made. Moreover, researchers continue to investigate alternative or non-traditional agricultural practices to minimize these inputs.

Options for use and disposal of wastewater from animal operations, such as dairies and swine operations, are becoming more limited in Indiana and throughout the United States. Discharge of wastewater is prohibited, land application is restricted, and reuse systems are not without problems. Reductions in nutrient loads can enhance wastewater use in rccycle systems and make utilization through land application easier. We are attempting to determine if constructed wetlands are a viable wastewater treatment option for small producers in the climate of Indiana and establish optimal operating conditions for such systems.

Methods

Planting of a 16-cell experimental constructed wetland at the Purdue University Animal Science Farm Swine Facility was completed in early May, 1994. After two months of vegetation establishment, wastewater from the final lagoon in a three-lagoon system was loaded into the system. Three hydraulic loading rates (450 Ld-1, 900 Ld-1, and 1800 Ld-1) and two water depths (15 cm and 30 cm) were tested. Three replicates of each combination tested were conducted, Three cells were used for a wetland plant seed germination study, and one cell was maintained free of vegetation. Water quality of cell influent and effluent was monitored throughout the growing season. Vegetation response to different hydrologic regimes was monitored.

Results

Water quality tests indicate shallow wetlands with dense vegetation and low hydraulic loading rates perform best in treating swine wastewater. However, greatest reductions in ammonia-nitrogen were achieved in the unvegetated cell. This may have resulted from three factors (singly or in combination): 1) pH fluctuation induced by algal photosynthesis could have resulted in precipitation of ammonia compounds; 2) greater exposure to oxygen from algal photosynthesis and exposed water surface might have allowed greater nitrification rates; and 3) volatilization of ammonia into the atmosphere would have been enhanced by open water. Results from two additional studies at Indiana dairies are comparable.

Vegetation performed better at shallower system operating depths. This was true for all plants tested. Broad-leaf cat- tail (_Typha latifolia_) displayed the greatest vigor, both in individual plant health and plant colony density. Softstem bulrush (_Scirpus validus_) had the next best performance. These two species continued to grow when subjected to extended loading with ammonia-nitrogen levels in excess of 250 ppm in late summer and fall. Mature plants continued to grow, but clonal expansion from rhizomes was reduced. Narrow-leaf cat-tail (_Typha angustifolia_), three-square bulrush (_Scirpus acutus_), and common reed (_Phragmites australis_) performed poorly or died out within cells. Both three-square bulrush and common reed were eliminated from cells under continued loading at high ammonia-nitrogen levels.

Discussion

The utilization of biogeochemical processes found in natural wetlands as mechanisms in the treatment of urban, industrial, and agricultural wastewater has been in development for over forty years. We know that constructed wetlands work- where questions remain is under what conditions are wetlands successful and, equally importantly, where do they fail (DuBowy and Reaves 1994). Additionally, design criteria and best management practices need to

be developed to help federal and state agencies with the permitting, implementation, and monitoring of projects. This is not to imply that a single blueprint will ever be developed for all constructed wetlands- they will continue to be planned and constructed on a case-by- case basis.

Over 20 constructed wetlands facilities have been built around the country for the treatment of animal waste (DuBowy and Reaves 1994). Constructed wetlands have been shown to be effective for the reduction of nitrates, nitrites, ammonia, phosphates, suspended solids, BOD5, and coliform bacteria in effluent from feedlots and milking parlors. Our three constructed wetlands systems in Indiana consistently have achieved reductions of up to >90% in these parameters (Reaves et al. 1994a, b). Design criteria suggest a knowledge of waste- stream characteristics (water quality parameters), hydraulic loading rates, retention time, and soil porosity (Reaves et al. 1994c) are important when developing constructed wetland systems for livestock waste. Pitfalls and future research needs include system efficacy in cold weather, potential groundwater contamination, and reuse of treated water.

There has been much debate among constructed wetland researchers about the merits of multi-species vegetation assemblages versus monocultures. Because farm wastewater is highly variable, hardy plants that tolerate system stresses appear to be the best choice. This may result in decreased plant diversity, but it makes little sense to establish plants that could easily be killed by an episodic change in wastewater quality. In Indiana the active treatment season only lasts into December. Winter ice-up and declines in microbial transformation rates make system operation through the winter impractical. Systems with established vegetation should be able to be flooded by mid-May. This gives an active treatment period of six months. For constructed wetlands to be viable in northern states, operators need a means of storing wastewater for the other six months.

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CONSTRUCTED WETLANDS FOR SEDIMENT CONTROL AND NON-POINT SOURCE POLLUTION ABATEMENT AT US ARMY CORPS OF ENGINEERS PROJECT: RAY ROBERTS LAKE, DALLAS, TEXAS, AND BOWMAN HALEY RESERVOIR, BOWMAN, NORTH DAKOTA

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Two wetlands recently constructed at Corps of Engineers reservoirs were monitored for their ability to remove non-point source pollutants from storm run-off and possibly improve reservoir water quality. The two sites were the Spring Creek wetlands a 23 acre emergent marsh constructed in 1991 on Bowman Haley Reservoir near Bowman, ND, and a five acre wetland constructed in 1992 as part of a larger wetland complex on Range Creek, a major tributary of Ray Roberts Reservoir near Dallas, Texas. Research sites were selected based on either known or probable water quality problems within the reservoirs and the availability of constructed wetlands at the reservoirs.

Because most non-point source pollutants are delivered to a stream or reservoir after a significant run-off event, sampling efforts focused on storm events, with less emphasis on base or low flows. Intensive sampling of selected storm events was conducted during the period from spring of 1992 to the fall of 1993. Automated sampling systems were used to sample selected run-off events and provided detailed, time varying inflow and outflow pollutant concentrations during and following storm events. Samples were analyzed for suspended sediments, nutrients and selected herbicides. Sampling techniques are indicated in Figure 1 which shows the sampling equipment installation at an inlet culvert. Actual sampling techniques and equipment varied depending upon inlet and outlet configurations. Flow and concentration data were used to determine treatment effectiveness for suspended sediments and nutrients.

Results from the two sites varied, yet the wetlands were generally capable of removing suspended sediments from inflows while being less efficient at removing dissolved non-point source

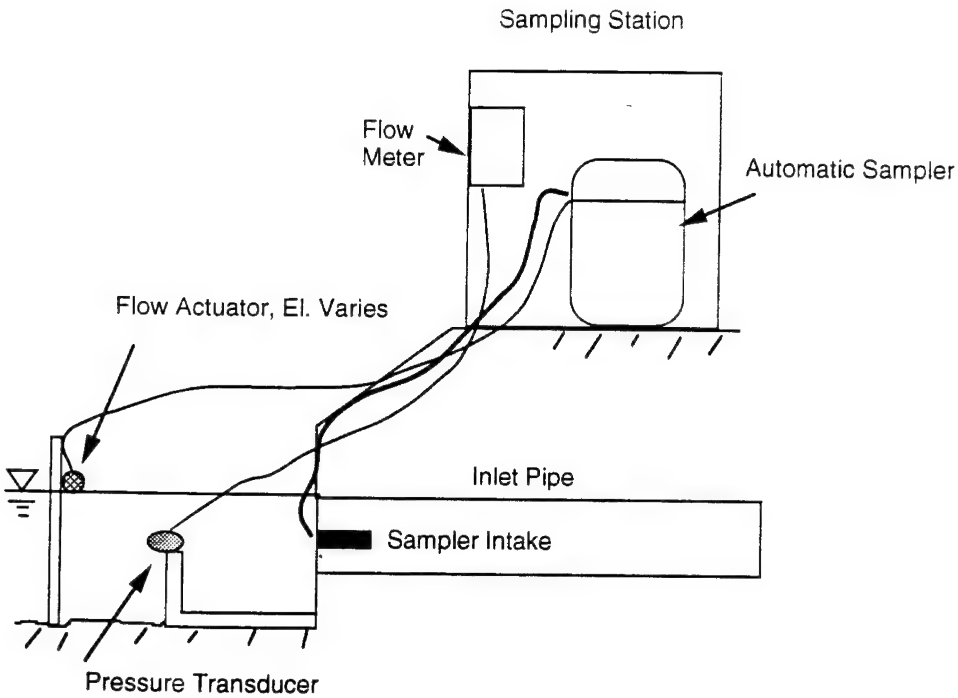

Figure 1 - Sampling equipment installation

pollutants. The Spring Creek wetlands at Bowman Haley Reservoir, was capable of removing a significant portion of total phosphorous, approximately 40 percent. Neither wetland was effective at nitrogen or herbicide removal. Figure 2, shows inflow and outflow total suspended solids (TSS), total phosphorous, and total Kjeldahl nitrogen concentrations from the Spring Creek wetland during a high rainfall period during July 1992. This figure typifies the results at this site, good removal of TSS, fair removal of phosphorous, and poor removal of nitrogen.

Hydraulic retention times of the wetlands were determined by conducting tracer dye studies. Rhodamine WT fluorescent dye was instantaneously released at the wetland inlet and the concentration at the outlet was monitored with a Turner fluorometer. Temperature corrected data were analyzed by Levenspiel's method (Levenspiel 1972). Hydraulic retention times were estimated to be on the order of 5 days for the Spring Creek wetland site at Bowman Haley Reservoir and on the order of 5 hours for the wetland studied at the Range Creek wetland complex at Ray Roberts reservoir. These hydraulic retention times are thought to be insufficient for the removal of herbicides at both sites, and also insufficient for the removal of nutrients at the Ray Roberts site.

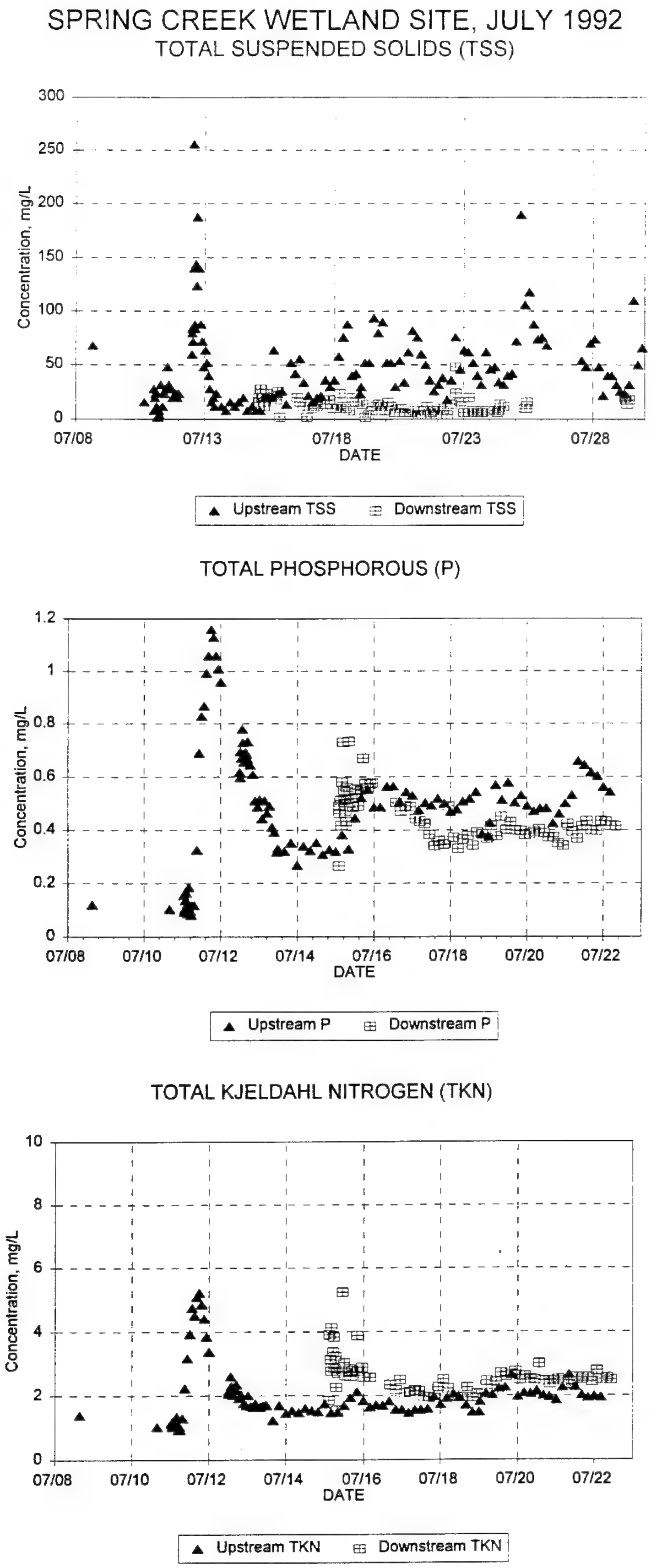

Figure 2 - Example data from Spring Creek Wetland Site

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A PROPOSED AMENDMENT TO THE EXEMPTIONS OF SECTION 404 OF THE CLEAN WATER ACT REAUTHORIZATION

Steven Whitesell, Sharon deMonsabert, PhD, and Deborah Branson

Abstract

Our paper will concentrate on a proposed amendment to the sequencing requirements of §404 of the Clean Water Act. This proposal is provocative because it directly implicates the function/value debate associated with wetlands and how such debate infiltrates both the sequencing strategy of existing §404 and the classification and mitigation schemes outlined in the major reauthorization bills.

This specific type of wetland mitigation involves the construction of a wetland ecosystem for the purpose of non-point source pollutional abatement. Certainly, any concomitant benefits of the wetland are welcome but the objective is to attack a serious problem associated with stormwater run-off.

The legal and policy analysis will show how the wetland regulatory process will need flexibility within the new law to allow innovative approaches that promote and protect wetland resources while offering solutions to site specific environmental problems.

Introduction

Wetlands often improve water quality by filtering out sediments and by absorbing nutrients and pollutants. In addition, wetlands provide rich habitat for a variety of fish and wildlife species. Forested wetlands in particular play a major role in stream ecosystem ecology by moderating water temperatures, contributing food matter, controlling upland run- off into streams, and stabilizing stream banks.ŖU.S. Department of Interior, 1994.

These beneficial effects are protected under Section 404 of the Clean Water Act which authorizes the Secretary of the Army to issue permits for the discharge of dredged or fill material into the waters of the United States, including wetlands. This section requires a sequencing mechanism through the Corps of Engineers public review process. A developer, whether public or private,

must first show that he has avoided wetlands to the extent practicable. After crossing this threshold the developer must show that he has minimized adverse impacts. As a third step, only after the exhaustion of the first two, mitigation is appropriate.

The fundamental purpose of the Clean Water Act is to restore and maintain the chemical, biological, and physical integrity of the nation£s waters. To be true to this purpose, a more balanced approach to the management of wetland resources is in order. For example, a Navy development that impacts wetlands must be in compliance with Section 404 of the Clean Water Act. However, if it can be shown within the Corps public review process that positive environmental impacts can result from a wetland management technique, then such technique should serve as justification for a modification to the sequencing process. Specifically, if wetland restoration or creation on site can be shown to reduce the effects of non-point source pollution, particularly in estuarine areas, then up-front mitigation should be authorized.

Scientific Evidence

In order to treat pollution in a sustainable and relatively inexpensive manner, much exploration into the use of natural or created wetlands has been done in the last 10 years. There are several unanswered questions with the technique. It is certain that wetlands remove pollutants but how long can the system continue to function effectively? Maintenance requirements and intervals needed are being explored. The fate of pollutants and their effect on overall ecosystem are not well understood. Constructed wetlands, just like natural wetlands, fall under section 401 (k) of the Clean Water Act and are subject to regulation by the Environmental Protection Agency (NRC, 1993).

As a function of their design, wetlands can be effective in removing pollutants from stormwater run-off. Removal pathways include sedimentation, adsorption to sediments/vegetation/detritus, physical filtration of run-off, microbial uptake/transformation, uptake by wetland plants, uptake by algae, and extra detention and/or retention (Schueler, 1992). Nitrogen, in all forms, is removed biologically. Dissolved Organic Nitrogen (DON) is taken up biologically as well. Phosphorus in the sediment is removed by interaction with iron, aluminum, and calcium. Metals and suspended solids can be taken up by the roots and translocated. Bacterial action also reduces suspended solids. When conditions are optimal, 80% of the Total Suspended Solids (TSS) are removed by sedimentation. The metals and organics tend to be tightly bound to sediment particles.

NAWC (AD) Patuxent River,
Maryland Constructed Wetlands Research Project

In a joint research effort between George Mason University,

Public Works Department Patuxent River, MD, and the Chesapeake Division of the Naval Facilities Engineering Command, the ability of a constructed wetland to reduce the effects of sediment and hydrocarbon contaminated stormwater run-off from construction sites, aircraft runways, and parking lots is being evaluated. The purpose of this research is to demonstrate the beneficial uses of a constructed wetland for management of non-point source stormwater run-off. The results of this research should justify a modification to the Corps of Engineers sequencing process.

Proposed Amendment to Section 404
of the Clean Water Act Reauthorization

The ability of wetlands to improve water quality by filtering out sediments and absorbing nutrients and pollutants is protected under section 404 of the Clean Water Act. Actions which encourage the construction of wetlands as a mitigation measure should be encouraged because of the added environmental benefits that can be provided by a well designed and maintained wetland. Many existing wetlands because of their geographical location do not provide significant improvement to the quality of a surface water system. With this in mind it is recommended that the following language be added to the exemptions:

Any activities that are proven to benefit the purpose of this title as stated in section 101 not withstanding discrepancies with section 404."

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SESSION SM6

STEWARDSHIP AND MANAGEMENT:
FISH AND WILDLIFE HABITAT MANAGEMENT II
Chester O. Martin, Chair

CONSERVING BIOLOGICAL DIVERSITY: APPLICATIONS TO MANAGEMENT OF FRESHWATER WETLANDS

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The cumulative impacts of 5.5 billion people, a number growing by 95 million each year (260,000 per day) has fragmented, simplified, homogenized, and destroyed many ecosystems to the point that contemporary species extinction rates are estimated to be 1000 to 10,000 times higher than that expected in the absence of human influences (Meffe and Carroll 1994). The field of conservation biology is in part a response by the scientific community to this situation. Although attention has centered on loss of biological diversity (commonly termed biodiversity) in terrestrial ecosystems, especially tropical forests, wetland ecosystems also are important to the biodiversity-conservation effort. For example, although wetlands cover only about 5% of the land area of the United States, about 50% of the animals and 33% of the plant species listed in the U.S. as endangered or threatened are dependent on wetlands (Nelson 1989). Furthermore, wetlands are considered to be endangered or threatened ecosystems in several regions of the U.S. (Noss et al. 1995).

Wetland managers are being asked to place more emphasis on biodiversity and natural-community characteristics, while simultaneously maintaining other wetland functions and values (Laubhan and Fredrickson 1993). Effectively meeting this challenge will require individuals that understand the concepts and guiding principles of conservation biology, and are capable of integrating this knowledge with more traditional information on the ecology, management, status, and biopolitics of wetlands. Unfortunately, confusion exists regarding the application of biodiversity concepts, especially complex theory, to actual management

situations. In our opinion, this has created both frustration with and resistance to "biodiversity management."

Biodiversity is the variety of life forms, the ecological roles they perform, and the genetic diversity they contain. The concept of biodiversity has multiple levels of organization (i.e., genetics to landscapes) and includes structural, functional, and compositional components. Ecological and evolutionary processes are also considered part of biodiversity. Conservation biology is an integrative approach to the protection and management of biodiversity. The field differs from traditional resource conservation in being motivated not by single-resource oriented issues, but by the need for conservation of entire ecosystems and all their biological components and processes (Meffe and Carroll 1995).

Wetland management should be based on the following principles of conservation biology: (1) maintain critical ecosystem processes, (2) base management goals and objectives on an understanding of ecological properties, (3) minimize external threats and maximize external benefits, (4) understand and maintain evolutionary processes (i.e., maintain ecological conditions that favor maintenance of genetic diversity), and (5) establish adaptive management strategies. In more specific terms, wetland managers should identify critical wetland processes, understand wetland dynamics and ecological processes controlling a particular system, control invasions of exotic species, minimize disturbance to vulnerable species, incorporate population-level and landscape considerations whenever possible, and use adaptive management to provide feedback on success of management actions.

Managing freshwater wetlands for biological diversity does not necessarily require new management techniques. Traditional methods such as water-level manipulation, prescribed fire, mechanical and chemical treatment of vegetation, and control of non-native species will continue to be used. However, certain techniques likely will become more important as emphasis is placed on maintaining ecosystem integrity and biological diversity. These include strategies and techniques for restoring degraded habitats, recreating lost habitats, re-establishing viable populations of native species, identifying and protecting critical habitat components, and integrating the needs of a diverse assemblage of species (Giudice and Ratti 1995).

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WILDLIFE AND VEGETATION MONITORING OF CONSTRUCTED WETLANDS AT RAY ROBERTS LAKE, DENTON, TEXAS

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Ray Roberts Lake, constructed by the Corps' Fort Worth District, is located in north central Texas, near the Dallas-Fort Worth Metroplex. In an effort to further address environmental concerns in all phases of project planning, design, construction, and operations and maintenance, the Fort Worth District has conducted pre-impoundment and two-year post-impoundment environmental studies at Ray Roberts. The District is currently conducting a five-year post-impoundment study, including environmental studies of wetland cells that were constructed in 1992. Some research has already been conducted at the wetlands, however, there is a lack of detailed, long-term monitoring of vegetation and wildlife utilization of the area. The University of North Texas Institute of Applied Science is conducting vegetation and wildlife research that fills this research gap. This research will provide baseline data for future studies of the Ray Roberts wetlands, and expand our understanding of created wetland systems.

WETLAND RESTORATION AND MANAGEMENT AT THE RIVERLANDS ENVIRONMENTAL DEMONSTRATION AREA, POOL 26 - UPPER MISSISSIPPI RIVER SYSTEM

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The Riverlands Environmental Demonstration Area (EDA) is a 1200-acre restored prairie wetland located in St. Charles County, MO, immediately upstream from the new Melvin Price Lock and Dam in the Upper Mississippi River System. The wetland area was created by connecting a river backwater and floodplain ponds created by construction of the new dam.

Since its creation in 1990, the Riverlands EDA has been the focus of several monitoring and research investigations. Studies focused on water level fluctuations, vegetation, mussels, fish, birds, and mammals have provided much information to guide stewardship of the EDA. The EDA has also been subject to several ecological disturbances that have impacted management activities.

Monitoring revealed several factors important to wetland management in rivers regulated for navigation. Future management of the area will focus on river-wetland interactions that support high productivity and species diversity. Some rare or immobile species may require stocking to become re-established.

MANAGEMENT FOR BIODIVERSITY IN RIPARIAN ECOSYSTEMS ON US ARMY CORPS OF ENGINEER LANDS

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Riparian areas occur throughout the United States as linear areas along rivers, streams, and other aquatic habitats. The most extensive riparian areas in the United States are vast forests of bottomland hardwoods that occur along broad river floodplains in

the East. However, riparian areas are also important components of many western landscapes. Riparian areas are among the most diverse, dynamic, and complex biological systems on earth. These areas contribute significantly to regional biodiversity (Naiman et al. 1993) by providing essential habitat for a wide variety of plant and animal species. However, most streams and riparian areas have been significantly altered or destroyed. Riparian areas are often referred to as "wetlands," but these two terms are not necessarily synonymous (Ohmart and Anderson 1986). These ecosystems often extend beyond the boundaries of jurisdictional wetlands.

Riparian zones are considered an important natural resource on Corps of Engineers (CE) civil works projects throughout the United States. The majority of these projects are constructed along streams and rivers having adjacent riparian zones. The construction and operation of projects for flood control, water supply, navigation, and hydropower exert considerable stress on the riparian zone at many CE projects. These projects often modify natural flows and flooding regimes and divert ground and surface waters, thus producing substantial alterations to the riparian zone. Agriculture, timber harvesting, and recreation also affect riparian habitats.

Management of riparian areas typically focuses on maintaining or restoring a stable zone of riparian vegetation adjacent to the aquatic system (Gore and Bryant 1988). Riparian zones provide habitat that influences flora and faunal communities on a variety of scales (e.g., local, landscape) (Knopf and Samson 1994). Local communities are highly influenced by land-uses that occur within the surrounding watershed. Therefore, to properly manage riparian ecosystems for biodiversity, these ecosystems must be considered as an integral part of the watershed. Riparian habitat condition is often a result of the biogeochemical processes occurring among aquatic, riparian, and terrestrial ecosystems (Green and Kauffman 1989). In general, management applied to any one of these ecosystems may subsequently affect the other ecosystems. This is especially true for riparian and aquatic ecosystems when management occurs in upland areas of the watershed because results of the action will ultimately be realized at lower-elevation sites.

Management techniques for biodiversity include proper maintenance of riparian plant communities, and the establishment of buffer zones. Riparian zone width is often positively related to faunal species richness and density. Most notably, the abundance of neotropical migrant songbirds in riparian zones is positively correlated with riparian-zone width.

Future research needs on CE projects include, (1) examining the spatial attributes and dimensions (i.e., length, width), and vegetation characteristics that are required to provide a functional riparian system from a broad ecological perspective, (2)

determining how various land uses and activities affect riparian zone biodiversity, and (3) assessing the value of riparian zones to threatened, endangered, and other sensitive plant and animal species.

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SESSION FA1

ASSESSING WETLAND FUNCTIONS: HYDROGEOMORPHIC APPROACHES PERSPECTIVE

R. Daniel Smith, Chair

A COMPARISON OF CURRENT WETLAND ASSESSMENT METHODS

Richard P. Novitzki

Wetland assessment is needed to protect sensitive wetlands, to mitigate for unavoidable loss, and to assess mitigation success. The Wetland Evaluation Technique (WET) developed by Adamus et al. (1987) applies to all wetlands, is accepted by most federal agencies, and is used widely. EPA is developing the wetland component of the Environmental Monitoring and Assessment Program (EMAP) to estimate the condition of wetlands within a specific wetland class in a region, compared to reference conditions (Novitzki 1994). The Corps of Engineers is developing the hydrogeomorphic (HGM) approach for assessing the degree of function occurring in individual wetlands (within one wetland class), also compared to reference (Brinson 1993).

Wetland Evaluation Technique

WET was the first comprehensive approach to wetland assessment, and 17 Federal agencies, the National Wetland Technical Council, and many others helped to revise the method (Adamus et al. 1987). WET assesses function in terms of "social significance, effectiveness, and opportunity;" uses "predictors" of physical, chemical or biological processes (functions); and assigns value to function in terms of Social Significance.

The following functions are evaluated by WET:

Ground Water Recharge
Ground Water Discharge
Floodflow Alteration
Sediment Stabilization
Sediment/Toxicant Retention
Aquatic Diversity/Abundance
Nutrient Removal/Transformation
Recreation
Production Export
Uniqueness/Heritage
Wildlife Diversity/Abundance

WET uses features of the wetland's watershed, topography, vegetation, and others to estimate (using flow charts or computer software such as WETWorks) a probability rating of "High", "Moderate", or "Low" for each function (except recreation) and habitat suitability ratings for fisheries, wildlife, and waterfowl (Adamus 1988).

Adamus (1988) intended that individual wetland assessments be compiled to refine thresholds between Low, Moderate, and High in each region. Although this has not happened, WETWorks software creates an electronic file for each WET assessment performed, and a lead agency could create local or regional databases of WET assessments.

EMAP-Wetlands

EPA initiated the wetlands component of the EMAP to identify indicators of wetland condition, standardize measurement protocols, develop indices of condition, and establish a national network for monitoring wetland condition (Novitzki 1994). Wetland condition is defined as the state of selected characteristics which are associated with wetlands and which are valued by society. EMAP condition estimates will be based on measures obtained from a probability sample of wetlands (one class) in a region. These indicator measures will be compared to reference conditions, a recent approach in wetland assessment.

EMAP-Wetlands has identified the following wetland values:

BIOLOGICAL INTEGRITY--the sustainability of balanced, integrative, adaptive communities of organisms having species composition, diversity, habitat, and functional organization comparable to that of natural wetlands.

HARVESTABLE PRODUCTIVITY--the quantity and quality of service or product that wetlands provide (e.g., food, timber, wildlife, recreation).

FLOOD REDUCTION AND SHORELINE PROTECTION--reduction of flood peaks and dissipation of velocity and energy resulting from conveyance through, or temporary storage or retention of flood waters within, wetlands.

GROUND WATER CONSERVATION--reduction of ground water discharge resulting from impeded ground water flow through relatively impermeable soils typical in wetlands.

WATER QUALITY IMPROVEMENT--the assimilation of nutrients and other dissolved constituents by plants, retention of sediments and associated materials, and chemical conversions in wetlands that improve water quality.

Indices of wetland condition will relate to one or more of these values, and will be compared to those of the least impacted wetlands in the region (e.g., reference wetlands). One will likely be an index of biological integrity, combining indicators of plant and animal communities, similar to Karr's index of biotic integrity (IBI) for streams (Karr et al. 1986). Other indices may include habitat integrity, hydrologic integrity, and water quality improvement, reported in terms of similarity to reference or to biocriteria (thresholds defined in reference wetlands).

A Hydrogeomorphic (HGW Approach for Assessing Wetland Function and Value)

The U.S. Corps of Engineers began HGM to assess the physical, chemical, and biological functions of wetlands (Brinson 1993). HGM will revise, regionalize, and simplify, the WET approach.

HGM identifies the following functions:

Dynamic Surface Water Storage
Long Term Surface Water Storage
Subsurface Storage of Water
Energy Dissipation
Moderation of Ground Water Flow/Discharge
Nutrient Cycling
Removal of Elements and Compounds
Retention of Particulates
Organic Carbon Export
Maintain Characteristic Plant Communities
Maintain Characteristic Detrital Biomass
Maintain Spatial Habitat Structure
Maintain Interspersion and Connectivity
Maintain Distribution and Abundance of Invertebrates
Maintain Distribution and Abundance of Vertebrates

HGM will identify which functions that an HGM wetland class performs in a region, identify wetland and landscape variables (e.g., plant community, stem density, topography) that indicate a function is performed, and scale the variables to suggest the degree to which the function is performed. Variables in individual wetlands are compared to those of a sample of wetlands in the region (reference domain) to assess the degree to which the assessed wetland performs expected functions. A regional database, containing profiles of wetland variables for each HGM wetland class, will define the range occurring in the reference domain, similar to EMAP-Wetland's reference conditions. HGM represents a combination of the WET and EMAP-Wetland's approaches. If variables can't be measured, indicators of variable conditions may be used.

Conclusions

WET can provide a comparative analysis of all wetlands in a

region of interest (e.g., identify sensitive wetlands needing protection). This sets it apart from both HGM and EMAP that allow comparisons only within wetland classes. HGM assesses functions performed by comparing variables observed in the assessed wetland to those observed in reference wetlands in the region. HGM can identify functional loss resulting from wetland modification or loss, as well as compensatory remediation required. EMAP estimates wetland condition in a region, based on indicator measures obtained in a statistical sample of wetlands. Hence, EMAP information could provide the reference conditions database needed by HGM, so long as both programs use comparable wetland classes, use similar measurement protocols, and establish comparable variables (HGM) and indicators (EMAP). Software developed for HGM and EMAP should create standardized electronic copies of assessments for use by both programs and for subsequent analysis.

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A PROCEDURE FOR ASSESSING WETLAND FUNCTIONS BASED ON FUNCTIONAL CLASSIFICATION AND REFERENCE WETLANDS

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Over the past several decades scientists, government agencies, and the general public have become increasingly aware of the important role wetlands play in maintaining environmental quality. At a national level, the Clean Water Act has played an important role in regulating impacts to wetland resources. Section 404 of the Act directs the US Army Corps of Engineers (Corps), in cooperation with the US Environmental Protection Agency, to regulate the discharge of dredged and fill material in "waters of the United States" which by definition include wetlands and other special aquatic sites. As part of the 404 public interest review process, the Corps is required to assess the impact of a proposed project on wetland functions, and utilize the results in deciding whether to issue or deny a permit.

Assessing wetland functions is a challenge because wetlands occur under a wide variety of climatic, geomorphic, and hydrologic conditions. As a result, not all wetlands perform the same functions in the same way. In 404, the challenge is increased because the time and resources available for conducting an assessment are limited. As part of the Wetlands Research Program at the US Army Engineer Waterways Experiment Station, an assessment procedure is being developed for assessing wetland functions that is sensitive to both diversity of wetland types and programmatic constraints of 404.

The assessment procedure has referred to as the "hydrogeomorphic approach" because it begins by classifying wetlands on the basis of geomorphic setting, water source, and hydrodynamics which are the fundamental functional characteristics used in the hydrogeomorphic classification for wetlands developed by Brinson (1 993). Classification identifies groups of wetlands that function similarly. This allows attention to be focused on those functions that a wetland is most likely to perform and the specific characteristics and processes that control those functions. There are five basic hydrogeomorphic wetland classes including riverine, depressional, slope, flat, and fringe (coastal and lacustrine). Within a region, each of these classes may be subdivided into two or more subclasses on the basis of landscape and ecosystem scale factors. For example, the riverine class might include high gradient and low gradient subclasses. The number of regional wetland subclasses depends on the diversity of conditions in the selected region, and the objectives of a project.

For each regional wetland subclass the functions most likely to be performed are identified. For each of these functions an assessment model is developed that defines the relationship between specific characteristics of the wetland ecosystem and the surrounding landscape and the capacity of the wetland to perform the function. During the early stages of development an assessment model may be calibrated using the literature, expert opinion, or even best professional judgment. Eventually, however, model

calibration should be based on data collected from reference wetlands representing the range of conditions that exist in the region. Assessment models result in an index that reflects the ability of a wetland to perform a function relative to similar wetlands in the region. The functional indices can be applied in 404 to analyze design/location alternatives, determine project impacts, avoid and minimize, identify compensatory mitigation, and monitor compensatory mitigation.

The assessment procedure consists of a number of documents including a procedural framework, guidebooks for hydrogeomorphic wetland classes, and case studies. Future plans include research to test and refine the assessment procedure and assessment models, and to implement the approach nationally by developing assessment models and indices for additional regional wetland subclasses.

THE HYDROGEOMORPHIC APPROACH AS A BASIS FOR PROCEDURES OF FUNCTIONAL ANALYSIS OF EUROPEAN WETLAND ECOSYSTEMS

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Abstract

The Functional Analysis of European Wetland Ecosystems (FAEWE) project (funded primarily by the European Commission DGXII) is developing science-based procedures for evaluating the functional characteristics of river marginal wetland ecosystems (Maltby et al, 1994). Integral to the FAEWE procedures is the adoption of a hydrogeomorphic approach to facilitate the interpretation of wetland functioning. This approach and the parallel hydrogeomorphic classification of Brinson (1993) maintains that it is possible to make reasonable judgments on how physical properties (geomorphic setting, water source, hydrodynamics) can be translated into wetland functions. The FAEWE project utilizes a different scale and approach because of the greater importance of land use in wetlands within Europe. The FAEWE procedures rely on the successful identification and delineation of hydrogeomorphic units (HGMUs). A HGMU is described as an area of homogeneous geomorphology and hydrology/hydrogeology, and under normal conditions homogeneous soil. Vegetation, whilst integral to the ecosystem, is deemed not to be a primary element of a unit, but may nevertheless give vital information on soil and/or hydrological conditions.

This paper outlines some of the process studies utilized in assessing the performance characteristics of HGMUs along wetland catenas from valley slope to the channel margin at "pristine" and variously impacted sites across a major environmental gradient in Europe. Validation of the hydrogeomorphic approach is interpreted through an appraisal of process relationships. Examples from the study sites in Ireland, UK, France and Spain are provided describing the relationships between HGMUs and physical and biogeochemical processes, Table 1. Redox-water table variations confirm the separation of distinct HGMUs arranged along a catenary sequence, Fig. 1. Surface flooding patterns highlight hydrological differences in floodplain HGMUS. Differences in decomposition assays, measured using the cotton strip method separate floodplain and groundwater maintained units, Fig. 1. Results of studies on N-mineralization and plant production based on similar HGMUs at impacted and non-impacted sites are discussed to emphasize the affects of anthropogenic changes on wetland functioning.

Processes		Location	HGMU	Process relationships and rates
Physical	Redox potential	Torridge, UK	*Levée* *Floodplain backland* *Gentle slope*	WT -50 to -200cm, Redox +200 to +550mV WT 0 to -100cm, Redox -200 to 400mV WT +/- 0cm, Redox -200 to +200mV
	Flooding	Shannon, Eire	*Floodplain depression* *Floodplain elevation*	28.6% annual flood duration* 6.2% annual flood duration*
Biogeochemical	Decomposition	Torridge, UK	*Levée* *Floodplain backland* *Gentle slope*	CTSL per day winter 1.566, spring 2.762, summer 2.794, autumn 2.254 winter 0.916, spring 1.579, summer 2.566, autumn 1.099 winter 0.262. spring 1.316, summer 1.973, autumn 0.497
	N-mineralisation**	Torridge, UK	*Floodplain backland* *Gentle slope*	6.41 gN/m^2/15 weeks 0.83 gN/m^2/15 weeks
	P-release**	Torridge, UK	*Floodplain backland* *Gentle slope*	0.83 gP/m^2/15 weeks 0.58 gP/m^2/15 weeks
	Plant productivity**	Torridge, UK	*Floodplain backland* *Gentle slope*	642 $PROD/m^2$/15 weeks 328 $PROD/m^2$/15 weeks

Abbreviations used: WT water table; CTSL cotton tensile strength loss;PROD production.
* Averaged over 1980-93, figures from Hooyer A. (Maltby *et al,* in press); ** Figures from van Oorschot M.A. (Maltby *et al,* in press).

Table 1. Examples of distinct HGMU - process relationships.

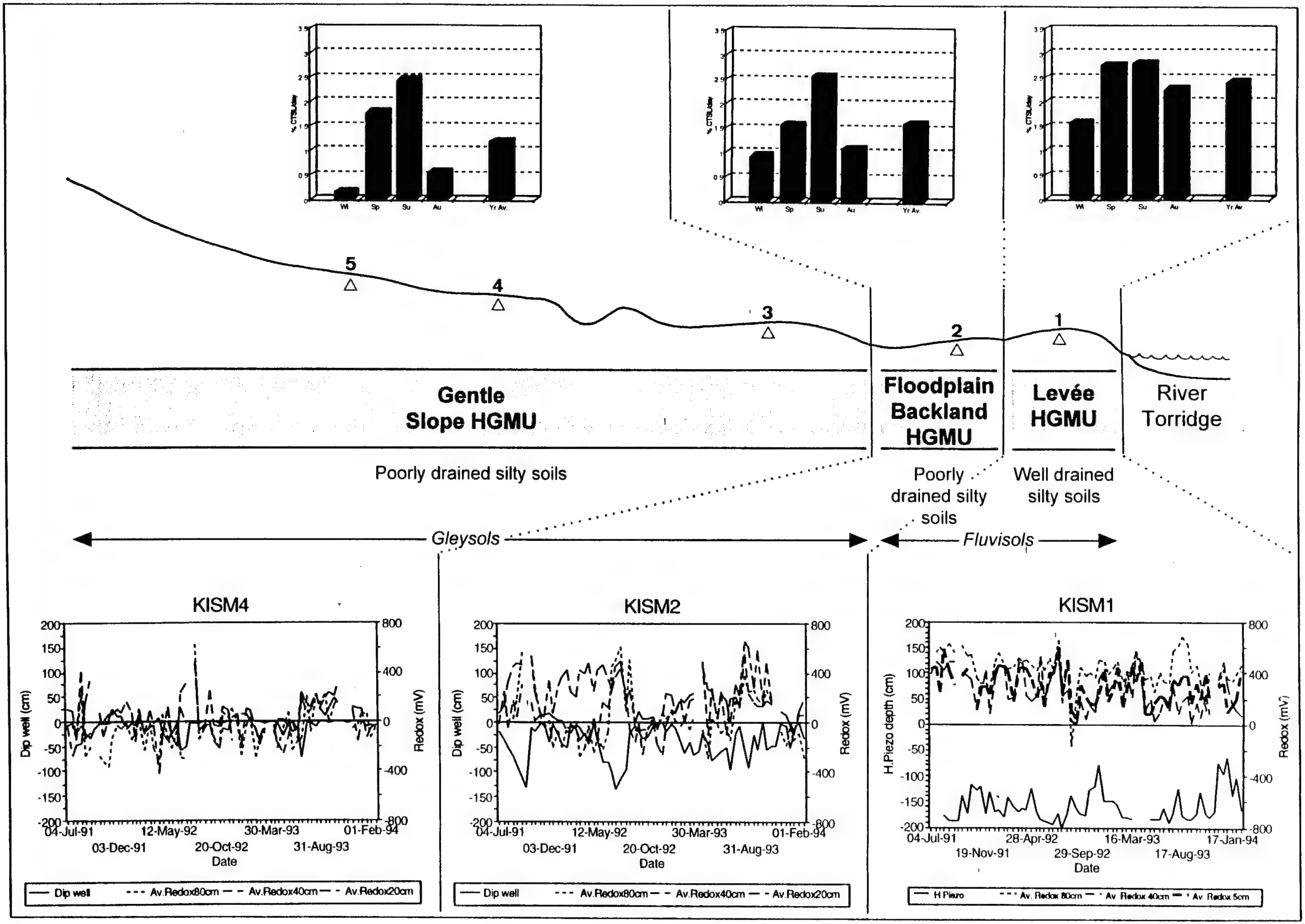

Figure 1. Relationship between HGMUs, redox-water table and decomposition rates, Kismeldon Meadows, River Torridge, UK.

The use and limitation of HGMUs as distinct functional entities is evaluated critically in respect of field trials and the results of extensive process studies. The applicability of the concept for predicting wetland ecosystem functioning within the FAEWE procedures is examined.

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NEW PROCEDURES OF FUNCTIONAL ANALYSIS FOR EUROPEAN WETLAND ECOSYSTEMS

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Abstract

The European Commission (DG XII: Science, Research and Development) is currently funding a major research program (Functional Analysis of European Wetland Ecosystems - FAEWE) to develop science-based procedures for evaluating the functional characteristics of European river marginal wetlands (RMW) ecosystems (Maltby et al, 1994).

The development of the FAEWE Procedures has adopted three approaches: (1) consultation with a potential user group (PUG), composed on government organizations and non-government organizations; (2) assessment, review and field testing of available functional assessment procedures; and (3) utilization of

the complete science-base developed within the FAEWE project.

Fig. 1 shows the overall structure of the FAEWE Procedures. A general Introduction to the FAEWE Project is provided. The User Guidelines are divided into four sub-sections, (i) which function to assess, (ii) which assessment approach to take, (iii) the level of detail of the assessment, and (iv) how to use the FAEWE Procedures. The Desk Study directs the user to existing data sources, advises on field equipment requirements, and assimilates the information into a preliminary assessment of the RMW. The FAEWE Procedures rely on the identification and delineation of hydrogeomorphic units (HGMUs). The HGMU delineation methodology divides the RMW on the basis of geomorphology (slope, depressions, elevations), hydrology/hydrogeology (precipitation, evapotranspiration, surface water, ground water), soil characteristics and vegetation community. Examples of field trials are presented. The Assessment Procedures offer either a qualified or a quantified output. The qualification assessment produces three outputs (i) the function is definitely being performed, (ii) the function is being performed, but only to a small degree, (iii) it is very unlikely the function is being performed. The outcome of the quantification is one of the three qualification outputs supported by a value of the ability of the wetland to perform the function. The third assessment level, modeling and monitoring procedures, details guidelines for long term studies of wetland functioning. It is at this stage that the Procedures become more than a simple functional assessment methodology and expand into a truly integrated set of procedures.

The assessments are based on identification and interpretation of the controlling variables that underpin wetland functions. Examples of the controlling variables for the nutrient removal function (denitrification) are provided in Table 1. 'Decision trees' based on interpretation of the controlling variables, synthesize key findings from the science base and computer models into an 'inference-engine', along with check lists and graphics to produce an accurate, user-friendly assessment format of the specific wetland functions. Examples are examined critically with respect to their practical application.

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Maltby, E., Hogan, D.V., Immirzi, C.P., Tellam, J.H. and Peijl, M.J. van der. 1994. Building a new approach to the investigation and assessment of wetland ecosystem functioning.
In: Mitsch, W.J. (ed), Global Wetlands: Old World and New. Elsevier, Amsterdam, pp. 637-658.

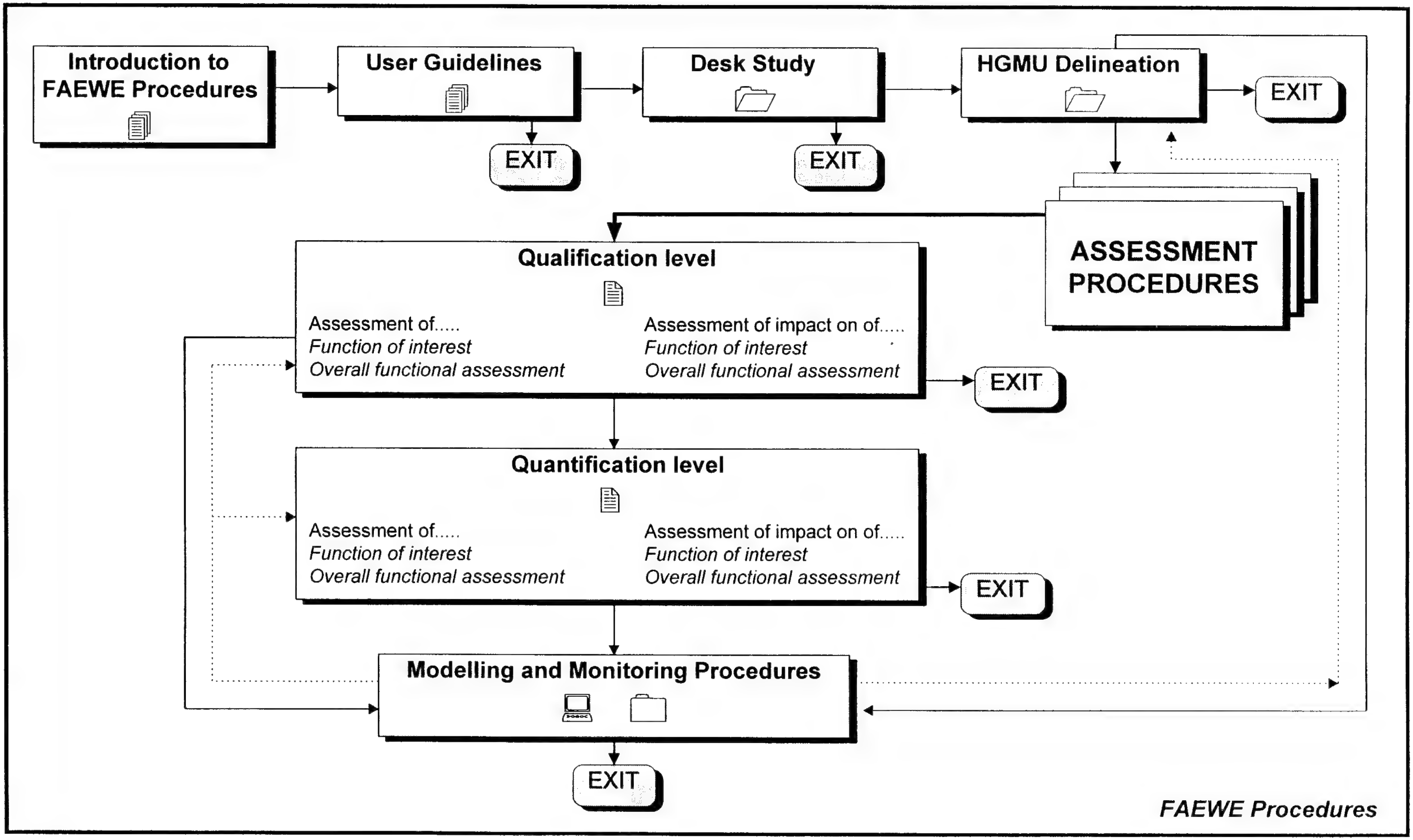

Figure 1. Overall structure of the FAEWE Procedures.

Controlling variable	Background rationale
• **Nitrate (NO_3^-) supply**	The presence or absence of a nitrate supply can often be the limiting factor for denitrification. Nitrate supply can be from sources external to the wetland (e.g. upslope nutrient rich agricultural run off), or from internal sources (e.g. as a result of mineralisation and nitrification). The supply of nitrate is also controlled by the hydrological pathways that are available for the conveyance of nitrate rich waters from the upslope areas into and through the wetland.
• **Soil oxygen (O_2) status (anaerobic vs. aerobic)**	The soil oxygen status will vary spatially and temporally. Highest rates of denitrification occur where alternating anaerobic and aerobic states exist. Nitrification will tend to occur under aerobic conditions and denitrification will tend to occur under anaerobic conditions. If the soil is predominantly anaerobic (e.g. gley soils) low rates of denitrification will exist due to the lack of nitrification. Thus the O_2 status of the soil will influence the internal source of nitrate.
• **Soil carbon (C)**	Soil carbon (organic matter) if not present in readily oxidisable forms may be a limiting factor for denitrification. The presence of carbon can stimulate microbial activity, reducing the O_2 availability and thus favouring denitrifying organisms over aerobic organisms that cannot assimilate C under anaerobic conditions.
• **Soil pH**	In general acid soils (pH < 7) have low rates of denitrification due to inhibited dinitrogen (N_2) production. In more alkaline soils (pH > 7) nitrous oxide (N_2O) is more readily reduced to N_2.
• **Soil temperature**	The optimum range of soil temperature for denitrification is between 60 - 65° However observations indicate that in real terms the highest soil temperatures coincide with the lowest soil moisture conditions, resulting in the occurrence of the maximum rates of denitrification at intermediate temperatures.
• **Environmental history**	The past and present environmental history of the wetland influences the composition of the soils and their microbial populations.
• **Synchronisation**	To achieve the maximum rate of denitrification all the optimum conditions for the above controlling variables must be synchronised in time and space.

Table 1. Controlling variables for nutrient removal (denitrification) function.

A METHOD FOR ASSESSING HYDROLOGIC ALTERATION WITHIN ECOSYSTEMS

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Hydrologic regimes play a major role in determining the biotic composition, structure, and function of aquatic, wetland, and riparian ecosystems. However, human land and water uses are substantially altering hydrologic regimes around the world. Improved quantitative evaluations of human-induced hydrologic changes would greatly benefit the development of ecosystem management and restoration Plans. To facilitate such improved hydrologic evaluations, we propose a method for assessing the degree of hydrologic alteration attributable to human impacts within an ecosystem. This method, referred to as the Indicators of Hydrologic Alteration (IHA), is based upon an analysis of hydrologic data available from existing measurement points within an ecosystem (such as at stream gauges or wells). We use 32 different parameters, organized into five groups, to statistically characterize hydrologic variation within each year. These 32 parameters provide information on some of the most ecologically significant features of surface and ground water regimes influencing aquatic, wetland, and riparian ecosystems. The hydrologic perturbations associated with activities such as dam operations, flow diversion, ground water pumping, or intensive land use conversion are then assessed by comparing measures of central tendency and dispersion for user-defined "pre-impact" and "post-impact" time frames, generating 64 different "Indicators of Hydrologic Alteration." The IHA method is intended to be used conjunctively with other ecosystem metrics in inventories of ecosystem integrity, in planning ecosystem management activities, and in setting and measuring progress towards conservation or restoration goals.

SESSION MB3

MITIGATION AND MITIGATION BANKING: STRATEGIES IN MITIGATION II

Ms. Lynn R. Martin, Chair

EXPEDITING WATER PROJECTS: BENEFITS ASSESSMENT AND WETLAND MITIGATION BANKING

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On behalf of the American Water Works Association (AWWA), CH2M HILL and King and Associates developed a handbook for water project development. The handbook is entitled "Expediting Water Projects:Benefits Assessment and Wetlands Mitigation Banking,"

The handbook gives practical information for meeting the objectives of both water resource development and environmental protection. The ultimate goal is to help water utility managers bring water resource projects on line quickly and cost-effectively while protecting and enhancing valuable environmental resources.

To help meet these objectives, two permit related activities are addressed:

1. Assessment of the beneficial environmental effects of water supply development

2. Use of wetland mitigation banking for all types of water resource developments

Technical And institutional data and methodologies are presented to assist in performing these activities. The data are from literature, field investigation, and conceptual plans for hypothetical wetland mitigation banks. The methodologies give general approaches as well as specific examples for assessing reservoir benefits and for developing successful wetland mitigation banks.

Examples were selected to bracket a typical range of potential water resource developments.

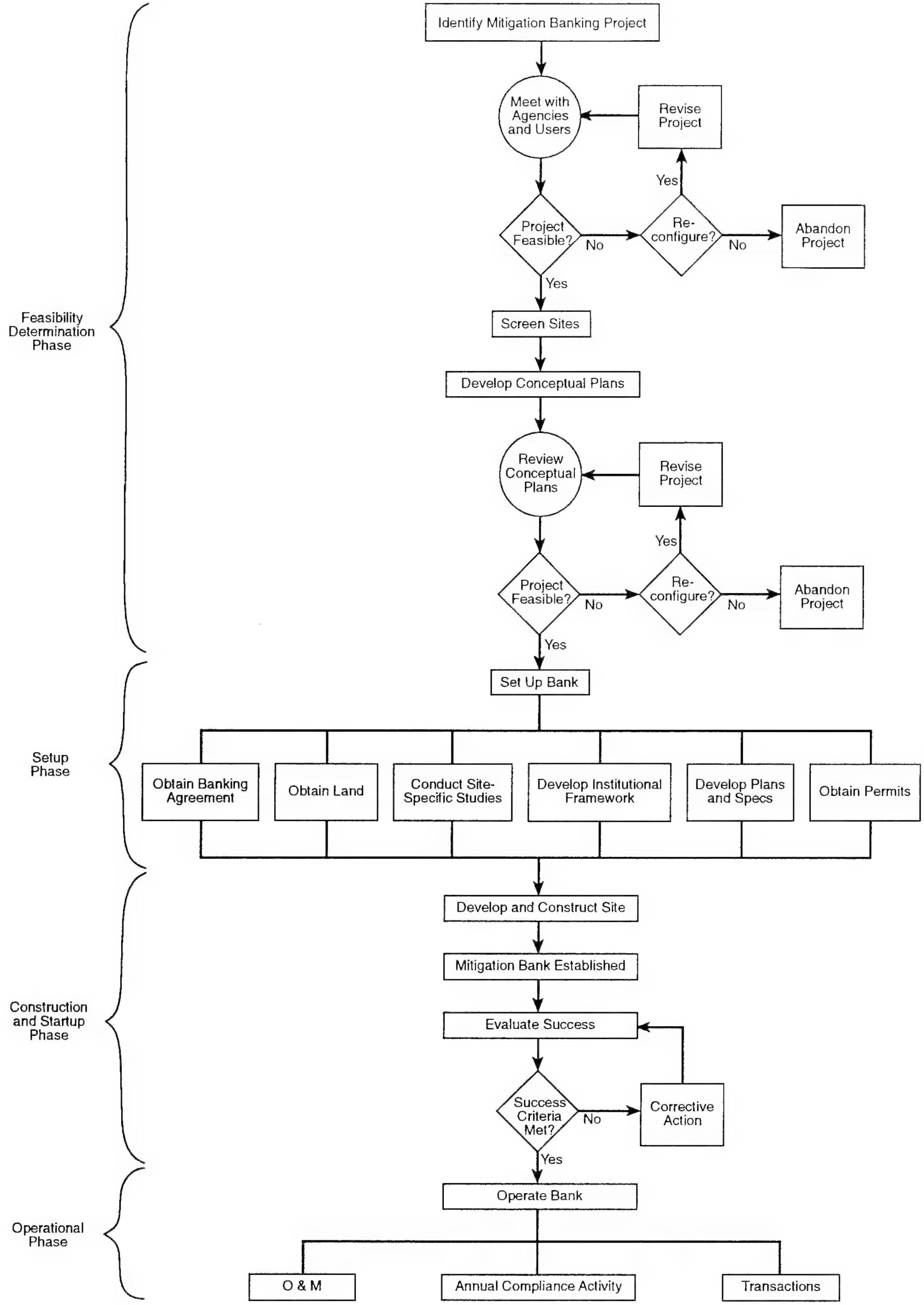

Figure 1. Mitigation Banking Project Activity Flow Chart.

Table 1
Key Features of Institutional Components1

INSTITUTIONAL COMPONENT	FEATURES
Bank Instrument	
The success of a mitigation bank depends on two things: (1) the way in which a mitigation bank is established, and (2) the roles various participants play in managing bank activities.	To establish a mitigation bank, the parties who will participate in the bank must enter into a formal, written agreement with the Corps and other concerned agencies. This agreement, referred to as a banking instrument, presents the guidelines for establishing and using the bank. In many circumstances, a mitigation bank may be established as a condition of a Section 404 permit.
Bank Management and Debiting	
Bank management and debiting is a two-step process. First, bank credits are evaluated for use in particular projects. Then, the resulting transactions are recorded.	For dedicated or single-user banks, the bank sponsor and regulatory agencies agree in advance, as part of the permitting process, on issues relating to the establishment and use of bank credits for future permitted projects. For commercial or general-user banks, regulatory agencies must exercise management oversight separately from the permitting process.
Bank Siting Process	
Regulators typically expect mitigation banks to be located in the same watershed as the wetland impacts they will be used to compensate for. The banks should be as close as possible to those impacts to replace important area-specific wetland functions and values that would be lost to development.	Regulators prefer bank sites in areas free from land uses that might threaten bank wetlands functions and values. Also, large areas of replacement wetlands are preferred because they avoid habitat fragmentation and promote biodiversity and establishment of self-regulating ecosystems.
Allowable Compensation	
The success of a bank is affected by the type of mitigation and by the timing of compensation and the geographical range of the permitted projects.	**Mitigation Type.** Regulators favor restoration of former or severely degraded wetland areas where hydric soils already exist and where the underlying hydrology is intact or can be restored relatively easily.
Compensation for each mitigation bank is based on wetland functions lost as determined during the Corps review. The Corps permit will specify how much mitigation is required after avoidance and minimization have been considered.	**Mitigation Timing.** Federal regulatory guidance for mitigation banking requires that bank replacement wetlands be "in place and functional" before they can generate usable bank credits.
Credit Valuation and Compensation Ratios	
Credit valuation involves the definition and evaluation of a mitigation bank's currency; compensation ratios establish the types and levels of allowable trades of bank currency for permitted wetland impacts.	The method used to evaluate bank credits is tied to bank- and area-specific wetland goals. The best credit valuation method for any particular bank is to use the simplest method that can achieve the specific wetland goals. Regulators expect compensation ratios to account for risk and uncertainty.
Quality Controls	
Several levels of quality controls must be developed for each mitigation bank as part of the overall bank establishment process. These are:	
Performance Standards and Success Criteria. A methodology acceptable to all parties involved must be established to assess the success of a mitigation bank. This methodology should identify the credits that will be issued at each stage of development and range of wetland functions to be assessed. The bank's functions, and the bank's credits and debits, should be evaluated.	Success criteria can serve one or more purposes. For example, they may be used to: (1) Determine when credits can be used; (2) Adjust compensation ratios at the time of credit use; (3) Guide monitoring and maintenance requirements on mitigation banks after they have generated usable credits; and (4) Define when mitigation failure has occurred after credit use.
Design Standards. On the basis of standards of practice and professional guidelines, project plans and specifications must provide design standards for a successful project.	
Monitoring and Maintenance. After a bank has been used to trade credits for permitted impacts, regulators expect it to be monitored to detect deficiencies in design, construction, or any stated success criteria. These plans should also include maintenance provisions to ensure that problems are corrected promptly.	Monitoring and maintenance programs provide the bank sponsor and regulators with regular and periodic assessments of the status of the bank. Monitoring plans typically address the elements detailed in the performance standards and success criteria.
Contingency Plans. Bank failures sometimes occur. Therefore, bank agreements must contain enforceable liability rules. These rules are important because banks might not provide fully functioning wetlands before credit trades occur. Liability rules assure that compensatory mitigation will be provided for each credit trade that is made.	Mechanisms can be used to reduce the likelihood that the public will have to assume financial responsibility for bank failure. These include surety bonds, trust funds, escrow accounts, collateral banks, and insurance systems. Regulators use several methods to ensure that bank sites will retain their wetland status after bank credits have been used.

MINNESOTA WETLAND CONSERVATION ACT: WETLAND BANKING SYSTEM

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The **MN Wetland Conservation Act (WCA)** is a "no-net-loss" state wetland protection program in effect since 1992. The WCA prohibits the draining and filling of wetlands unless replaced by restored or created wetlands of equal or greater public value under an approved replacement plan. Local government units (LGUS) administer this state program that includes a comprehensive yet simple wetland function and value assessment to achieve wetland replacement. The WCA also was the impetus for the development of a state wetland banking system which allows both public and private sector project sponsors to participate.

The **MN state wetland banking program** is incorporated as part of the WCA regulatory program, and was designed to be simple and flexible while conserving wetland functions and values. The banking program was based on federal models to assure maximum consistency with the mitigation requirements of Section 404 of the Federal Clean Water Act.

Wetland banking is a system of mitigation, or replacement of wetland acres and their associated public values lost due to draining, filling or other disturbance. Wetland banking allows the appropriate amount and type of wetland acreage to be purchased from an accountholder who has developed a "bank" of functioning wetland acres restored from previously drained or filled wetlands or newly created wetlands. Wetland banking is contrasted with project-specific replacement where the project sponsor does the restoration or creation specifically to replace a wetland that is to be drained or filled.

Principles of wetland banking are:

1. Functional wetlands must result. Expertise in site selection and construction techniques is required. Persons who have this knowledge or experience should be involved in the planning stages of banking projects.

2. Public funds cannot be used to subsidize wetland replacement for private projects. If a local government unit uses its property, funding, staff time for design and monitoring, or their resources to complete a wetland restoration or creation project and gain wetland banking credits, it must factor those items into the price it charges for the sale of wetland credits.

3. The resulting wetland area and type must exactly match those

credits in the bank. This means that all wetland size and type determinations (before and after) should be done conservatively.

Projects will be approved, managed, and monitored by LGUs and landowners with the Minnesota Board of Water and Soil Resources providing oversight and central record keeping. Public and private interests can buy and sell credits at costs determined by free-market factors.

WETLAND MITIGATION BANKING: SOLUTIONS THROUGH CONSENSUS BUILDING

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Argonne National Laboratory conducted a mitigation banking workshop sponsored by the Department of Energy, Metarie, LA. The workshop was held in Washington, DC in late March 1995. Invited participants included federal and state agencies that will be impacted by wetland banking regulations, legislative staffers who will be developing wetland banking legislation, industry representatives interested in using banking as a mitigation tool, and environmental groups interested in the effect of banking on wetland issues. The workshop was designed to stimulate discussion of various issues of banking including the environmental, regulatory and economic aspects. The results of the workshop should greatly help the legislative and natural resource agency staffs avoid pitfalls and deal effectively with industry and environmentalists concerns during the development of regulations, thus avoiding non-constructive controversies afterwards. The National Interagency Workshop on Wetlands seems an ideal place to present the results of the ANL/DOE workshop, by providing timely and pertinent information to other agencies, academia and the private sector.

WETLAND MITIGATION AT JORDANELLE WETLANDS AND THE SEEDSKADEE NATIONAL WILDLIFE REFUGE

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Jordanelle Wetlands

Jordanelle Dam and Reservoir, located on the Provo River 5,5 miles north of Heber City in northern Utah, were constructed recently by the Bureau of Reclamation (Reclamation) as part of the Central Utah Project. Mitigation required under the Clean Water Act Section 404 Permit for the project requires new wetlands be established to compensate for the loss of wetlands previously located in and around the reservoir. Riparian vegetation adjacent to the mitigation site, located at approximately 5,900 feet in elevation, is comprised of narrowleaf cottonwood, box elder, dogwood, and a variety of willows.

Objectives for the mitigation include the establishment of 92 acres of wet meadow vegetation; minimizing impacts to existing wetlands and riparian areas; creating and maintaining the maximum habitat diversity that is possible and practical within the operating limits and funding constraints; facilitating low-cost, long-term maintenance and management; enhancing western spotted frog habitat; and accommodating education and research uses of the wetlands.

Construction consists of 36 shallow ponds with low (two to five feet) earthen berms having sideslopes of 5:1 upstream and 3:1 downstream. Berms are constructed from topsoil material having a high clay content. Each pond has an outlet structure to provide regulation of pond elevation and conveyance of water to the next pond downstream. A water supply pipeline has been constructed with a turnout to 24 of the 36 ponds. The design allows for a large variety of operational schemes, one of which would require only five turnouts to operate the entire complex. Additional visual screening ditches, islands, peninsulas and isthmuses were made to provide physical diversity to the newly created habitat. Topsoiled areas of the ponds were planted with tubelings and tubers of hardstem bulrush, sedges, rushes, and sago pondweed.

The mitigation complex will be monitored closely during the next five years to encourage development of four to 10 acres of open water and 82 to 88 acres of wet meadow and riparian vegetation complex. A technical advisory committee, comprised of representatives from government, private, and public concerns provides guidance for the project which will serve as a valuable educational and wetland resource.

Seedskadee National Wildlife Refuge

Located on the Green River, just downstream of Fontenelle Dam in Sweetwater County, Wyoming, the refuge is an oasis amongst a mostly arid terrain. This refuge was constructed as part of the mitigation plan for construction of Fontenelle Dam. The Fish and Wildlife Service has responsibility for operations management and maintenance. One of the major objectives is to create wetland and

fish habitat. This year Reclamation, in cooperation with the Fish and Wildlife Service, constructed a river sill with the purpose of modifying the hydraulics of the river in order to divert flows to a historic oxbow (see Figure 2). This will greatly increase the fish habitat in the area and also raise the water table. The elevated water table will enhance wetlands along the oxbow.

FEE-BASED COMPENSATORY MITIGATION: POTENTIAL ROLES OF AND BENEFITS FOR CONSERVATION AGENCIES AND ORGANIZATIONS

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Wetland restoration is frequently required as a condition of 404 permits, as compensatory mitigation for adverse impacts to wetlands. Different approaches to satisfy mitigation requirements include on-site efforts, wetland mitigation banks, and fee-based compensation arrangements. As part of fee-based compensation arrangements, funds can be given to conservation agencies or organizations that facilitate wetland restoration. Programs normally supported by voluntary contributions could coordinate the disbursement of compensation fees. Potentially greater benefits could be achieved through programs designed to pool compensation fees to fund wetland projects that are larger and potentially more successful ecologically, than individual mitigation efforts. Such programs can be attractive to permittees, regulators and conservation interests by enabling consolidation and more timely responses to applications that would otherwise require numerous individualized investigations. Such programs may also be designed to include explicit requirements facilitating long-term management.

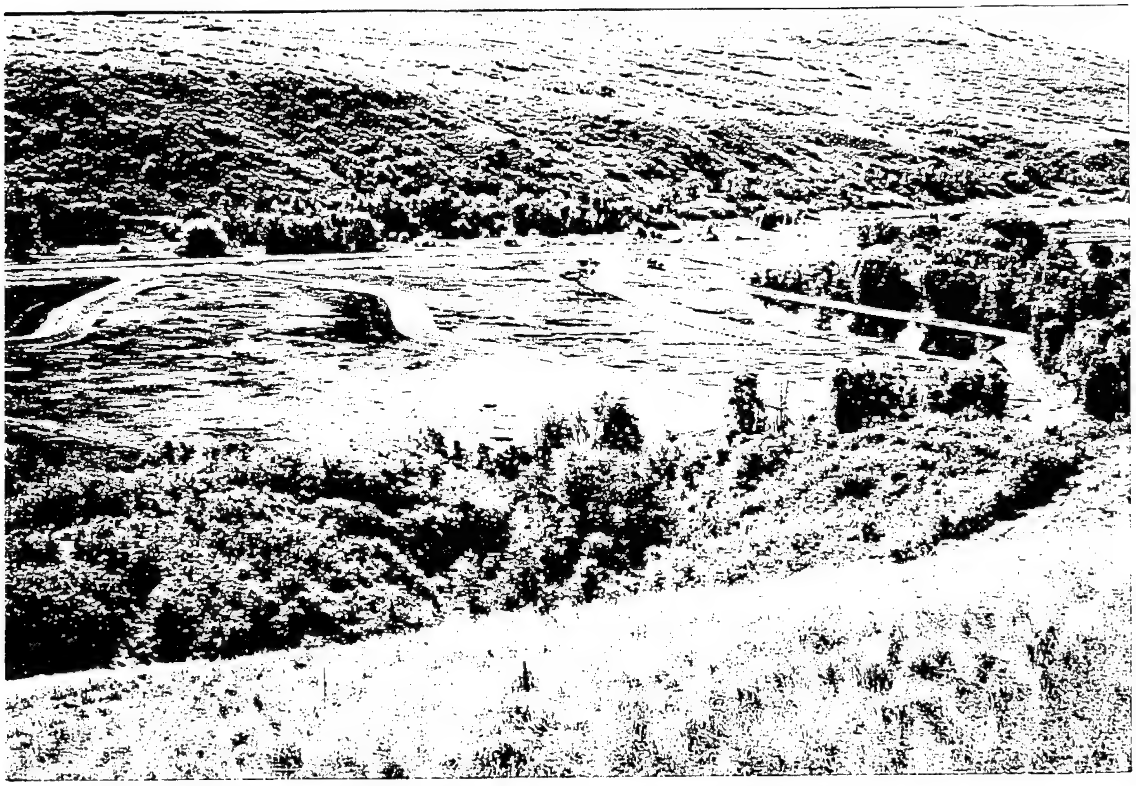

Figure 1. The Jordanelle Wetlands

Figure 2. Seedskadee Wildlife Refuge and McCullen Bluff Oxbow

SESSION RE13

RESTORATION, PROTECTION, AND CREATION: ALASKA AND PACIFIC NORTHWEST RESTORATION PROJECTS

Lloyd H. Fanter, Chair

AN EVALUATION OF THE WETLAND MONITORING PROGRAM OF THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

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WSDOT projects involving impacts to wetlands often require compensatory mitigation in the form of wetland creation, enhancement, and/or restoration under the terms of federal, state, and in some instances, local permits. Monitoring provides a systematic means of tracking the development of the wetland and its upland buffer over time, determines compliance with the permits, and can provide a critical source of feedback for future wetland mitigation efforts. WSDOT mitigation sites are typically monitored for five consecutive years. Annual monitoring tasks are conducted from May through September and include three formal breeding bird surveys, aquatic invertebrate collection and identification, soil and water sampling, vegetation identification, and photographic record keeping. WSDOT monitoring protocol is based on methodology described in Guide for Wetland Mitigation Project Monitoring (Horner and Raedeke 1989).

Three factors underscored the need for an evaluation of the WSDOT monitoring program: 1) the number of sites more than tripled since the inception of the program in 1988, (nineteen sites in 1994, with an expected increase to twenty-five sites in 1995), 2) the costs of wetland monitoring have increased by almost twenty-five percent over the same period, averaging $5000.00 per site in 1994, and 3) the criteria by which the mitigation sites are judged have evolved from broad-based, generically applied standards to directives tailored to the individual site. The combination of increased costs, higher standards for mitigation site development, and the increase in the number of sites monitored made it necessary to assess the monitoring program for efficiency and effectiveness.

Problem areas were found within each of the major components of the monitoring program: field methodology, data analysis, data interpretation and discussion, format of the annual report, and use of the results as feedback for future site design.

Specific problems with field tasks include: lack of standardization in number and location of soil and water samples collected; unavoidable bias in the collection of aquatic invertebrates; the need for additional wildlife surveys beyond bird surveys; and difficulties encountered in establishing a clear cut boundary between wetland and upland on a site where two of the three technical criteria necessary for wetland delineation often cannot be established. Specific recommendations were proposed with the intent of promoting standardization within the monitoring program, as well as providing a means by which to most efficiently gather the level of data necessary to comply with permit requirements.

The overriding problem found with the analysis of the monitoring data is the lack of a clear cut question to guide the collection of data. WSDOT wetland monitoring has been primarily motivated by the need to satisfy wetland regulation, not wetland research needs. The effect has been that the collection of data lacks focus; monitoring tasks are perfunctorily conducted and reported, which in turn gives a lack of continuity and depth to the discussion of the results in the annual monitoring report.

In any document report format is a critical component to facilitating the understanding of the contents by the reader. Minor changes to current report format will vastly improve the presentation of and reception of the monitoring results. To date the data analysis presented in the annual report have not been fed back into to the overall wetland mitigation program. Lack of time, difficulty with the report layout, and being unaware of the existence of the monitoring report are several of the reasons cited by WSDOT personnel for not utilizing information generated by the monitoring program.

It is important that the WSDOT monitoring program remain flexible; further refinements to the methodology may be necessary in the future if (or as) the mitigation requirements for impacts to wetlands change. Time constraints will become a limiting factor if the total number of sites monitored one season continue to increase. Potential budget restrictions may also become a factor affecting the program. To be the most efficient and effective in monitoring its created wetland mitigation sites, WSDOT should continue to work with federal, state, and local agencies in an effort to establish common ground on the expectations for and the focus of the monitoring program. There should be a consensus on where the emphasis of monitoring is placed, developed out of a realistic assessment of what can be achieved.

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PARTNERSHIPS IN MANAGEMENT BY EXPERIMENTATION FOR GRAVEL PAD REHABILITATION ON ALASKA'S NORTH SLOPE

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Christopher J. Herlugson
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Alaska encompasses 403 million acres with 174.6 million acres (43.3%) classified as wetlands. The 20 million acre Arctic Coastal Plain contains 16.6 million acres of wetlands. Most North Slope oil and gas development activities occur in these permafrost wetlands. Since 1979, over 900 U.S. Department of Army (DA) permits authorized placement of fill material on over 32 square miles of the North Slope. Over 21,000 acres of North Slope wetlands have been filled for petroleum and related development activities, including the Trans-Alaska Pipeline System (TAPS) and the Dalton Highway north of the Brooks Range. Approximately 2 percent (5,400 acres) of the 232,190 acre Prudhoe Bay Unit and 0.8 percent (2,530 acres) of the 326,592 acre Kuparuk oil field wetlands have been covered by fill material.

Many DA general and individual permits issued for placement of fill material on the North Slope stipulate that upon abandonment the area shall be rehabilitated to the satisfaction of the District Engineer. Where not specifically conditioned, DA permit general condition 2 states that upon abandonment, restoration may be required. The State of Alaska takes a longer term and larger scale view in conditioning leases by stipulating that upon abandonment the total lease tract (which may contain multiple DA permit sites) will be rehabilitated to the satisfaction of the State. No definitive standards have been established for determining what constitutes it satisfaction" for compliance with permit or lease conditions by the regulatory agencies. Currently, on DA permits, requirements for rehabilitation of wetlands are determined on a case-by-case basis.

Determinations of agency satisfaction and wetland rehabilitation success can be: problematic, controversial when individual Federal and State agency's responsibilities conflict, and compounded when a third party is financially responsible. Conflicts arise even in the use of the simple terms, e.g. restoration vs. rehabilitation, conservation vs. preservation, etc.

Does creating beneficial upland habitat preclude wetland rehabilitation requirements? Even the issue of short vs. long term rate of recovery is problematic, let alone considering natural vs. enhanced recovery.

Agency satisfaction and rehabilitation success can be achieved when regulators, land managers and permit holders are committed to mutual goals. These partnerships in management by experimentation by regulatory agencies and industry (e.g. Corps of Engineers, BP Exploration (Alaska) Inc., etc.) provide valuable data in determining appropriate rehabilitation goals and development of practicable/cost effective techniques. Annual results from BP Pad (rehabilitation, figure 1), X-Pad (corrective action) and Pebble Creek (restoration, figure 2) are being used in developing and improving specific rehabilitation goals, design criteria, and performance standards that will maximize the environmental and economic efficacy in future large scale rehabilitation efforts. Partnerships provide the necessary framework to facilitate successful rehabilitation within environmental constraints while meeting both the spirit and intent of regulatory compliance requirements.

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EVALUATION OF LIQUID CALCIUM (LCA-11) IN REDUCING SALINITY FOR ARCTIC TUNDRA REHABILITATION

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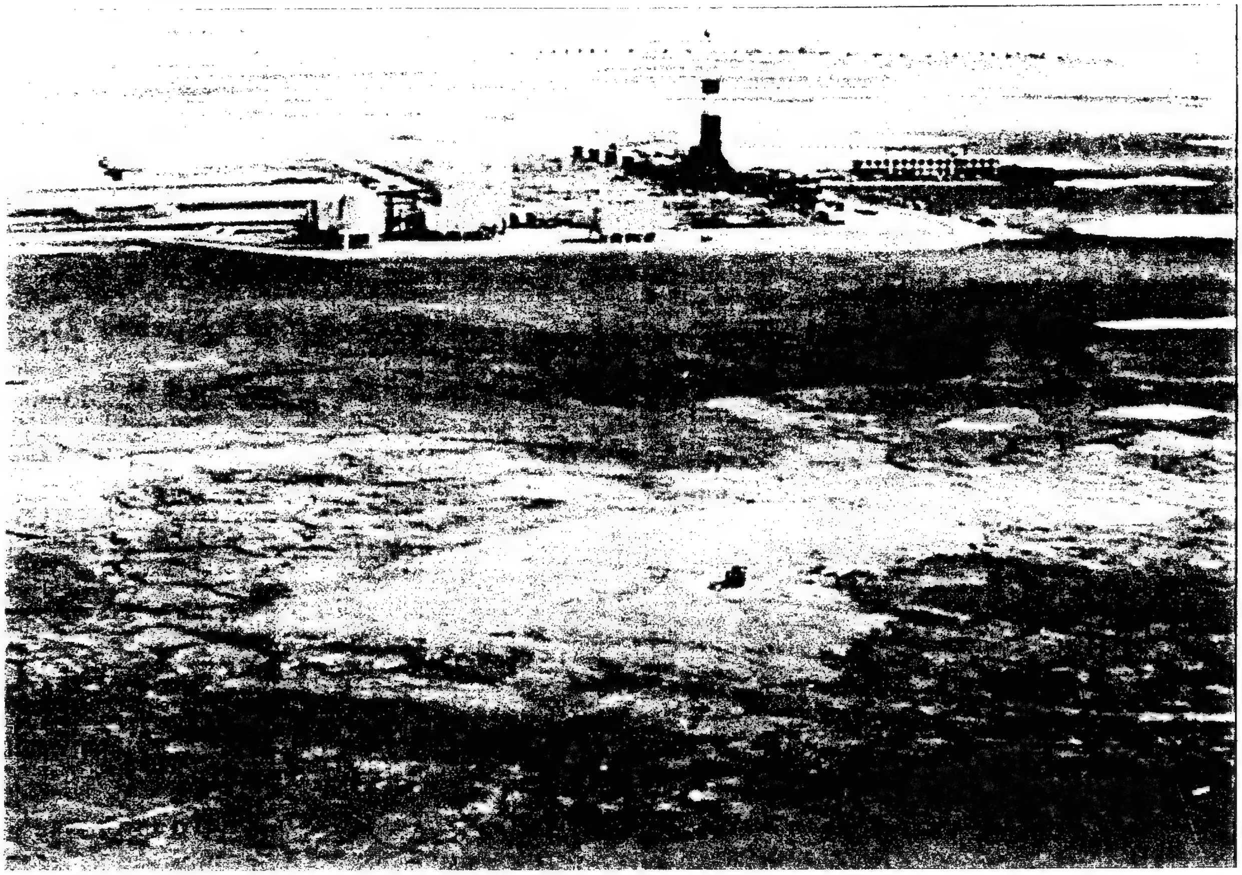
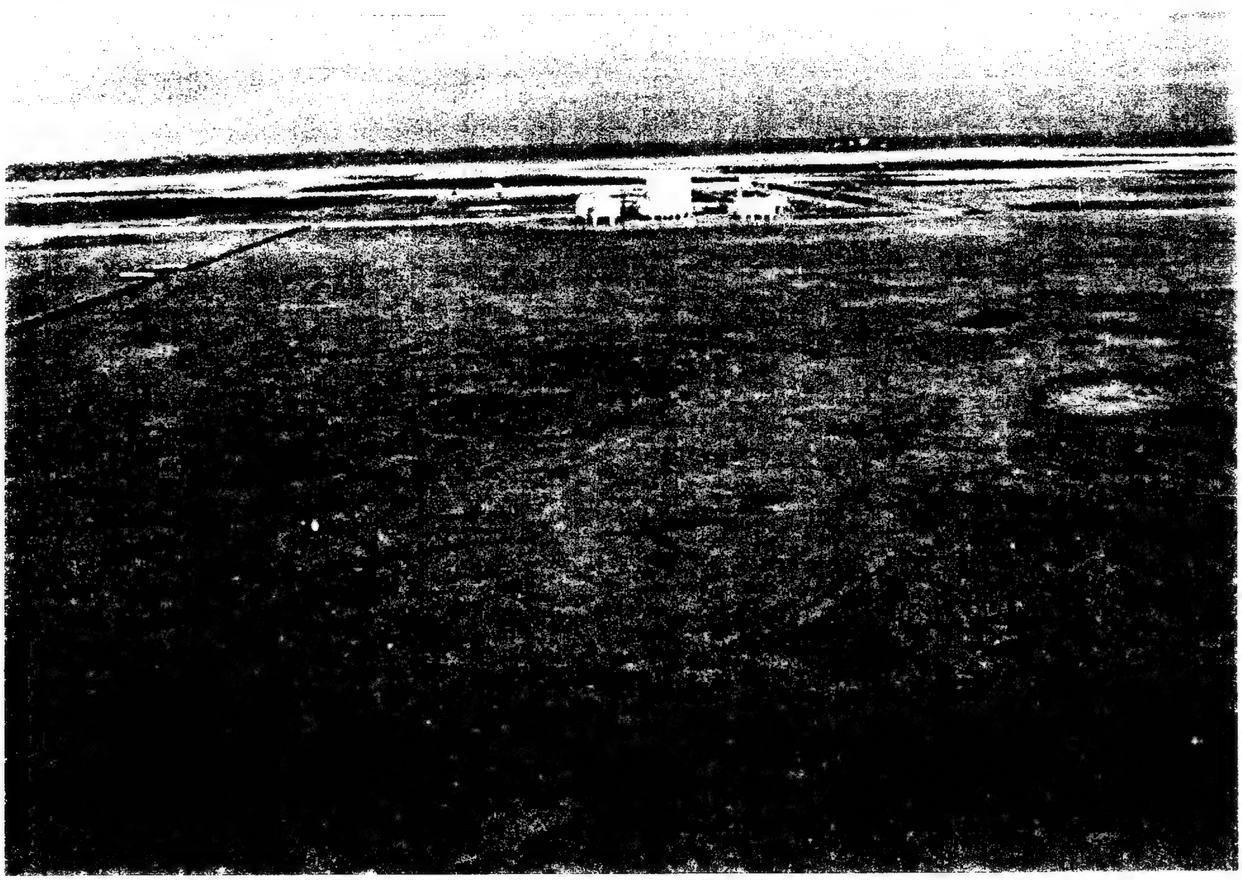
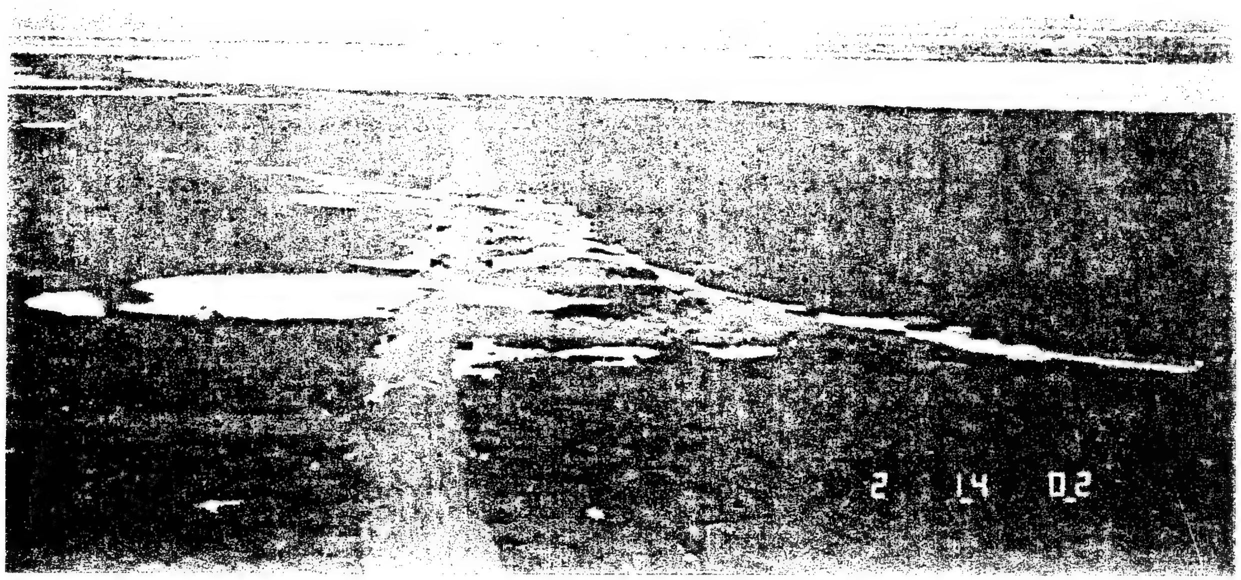
A revegetation project at an unused 93,000 sq. ft. flare pit (gravel-fill construction) was undertaken during the winter of 1989



BP PAD (PUT RIVER 22-33-11-13) 7/3/88



BP PAD (PUT RIVER 22-33-11-13) 7/3/93



PEBBLE CREEK 8/7/89

PEBBLE CREEK 7/1/91

to remove the gravel and revegetate the site. The site was seeded with a mixture of three tundra grasses (Arctagrostis latifolia, Festuca rubra, and Poa glauca) and fertilized. Following additional site work in 1990-9 1, the site was again seeded and monitoring continued. During the 1992 growing season it became clear that the revegetation project was failing. Soil tests indicated elevated salinity was the most likely reason for revegetation failure. It was theorized that the salinity of the soil was elevated prior to the flare pit rehabilitation project. The salts had migrated to the surface of the added layer of topsoil and were interfering with seedling establishment.

A joint experimental corrective action plan was formulated in 1993 by the United States Army Corps of Engineers-Alaska District (USACE) and BP Exploration (Alaska) Inc. (BPX) for the X Pad flare pit. The plan was developed to test the effectiveness of LCA-11, a calcium nitrate solution, as a treatment for rehabilitating saline soils. Testing and monitoring was scheduled for 1 September 1993 through 31 August 1996. Four field experimental plots (Blocks 1-4) were established. LCA-11 was applied to three plots which were seeded with native tundra grasses. A fourth block of plots was established to test the chemical on live plants, which had naturally colonized the flare pit area.

Soil salinity and vegetation response to the treatment were quantified after the 1994 growing season. Because some natural recolonization was occurring on the site, the entire area was sampled to measure plant cover and community composition. Photo plots were established to monitor vegetation changes over time.

Results

Average conductivity (salinity) of the soil surface decreased about 34% front 1993 to 1994. There was no statistically significant difference between salinity in control and treated soils. Total plant canopy cover, based on transact sampling within Blocks 1-4, averaged nearly 26% and total cover, including vascular plant basal cover, moss and algae, was about 63%. Treatment with LCA-11 increased cover of established plants and did not inhibit germination of native species, such as Puccinellia langeana. The decision was made to continue monitoring the site through 1996 without further LCA-II treatment. The current reduction in salinity and recolonization by native vegetation were prime factors in this decision.

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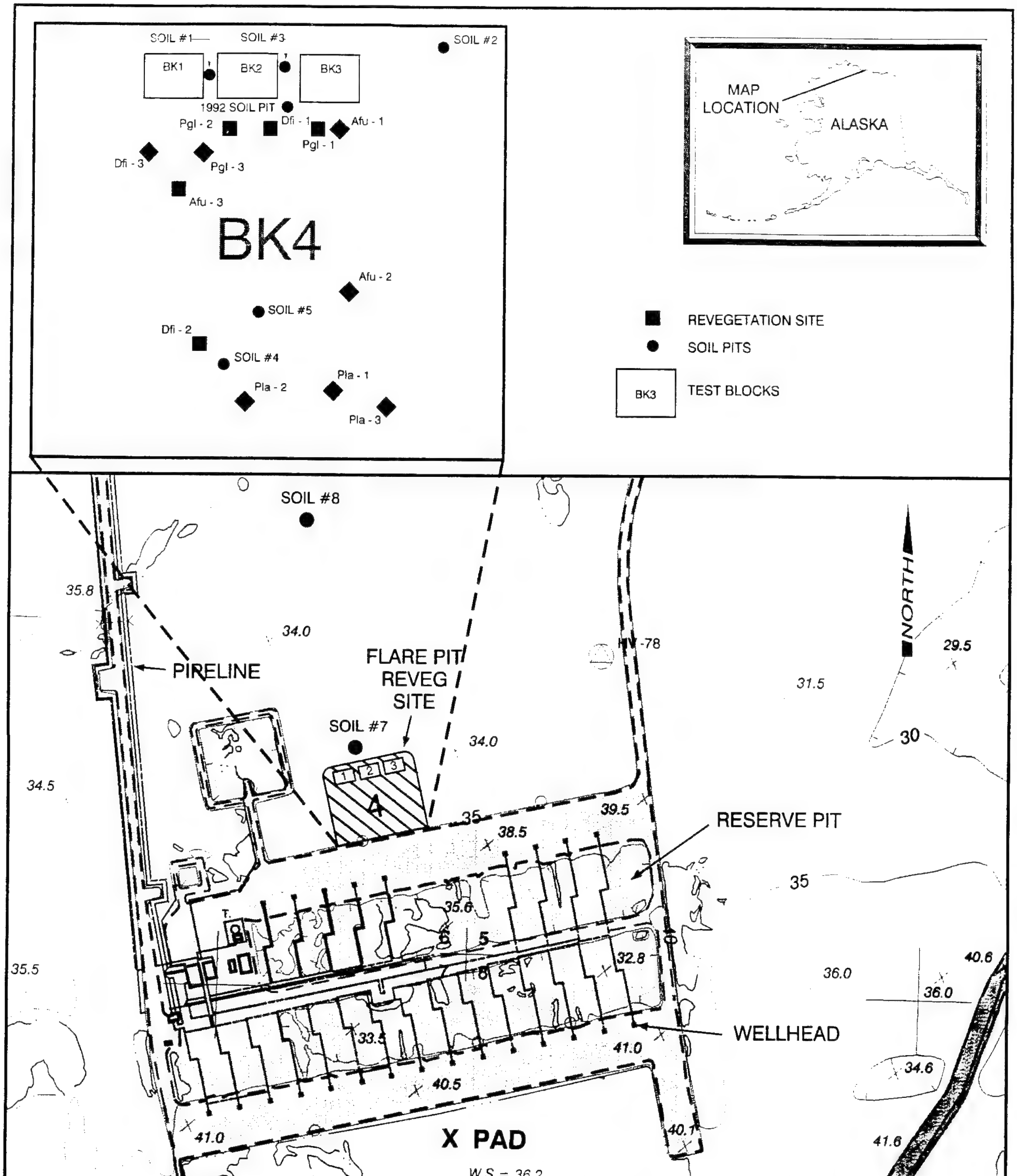


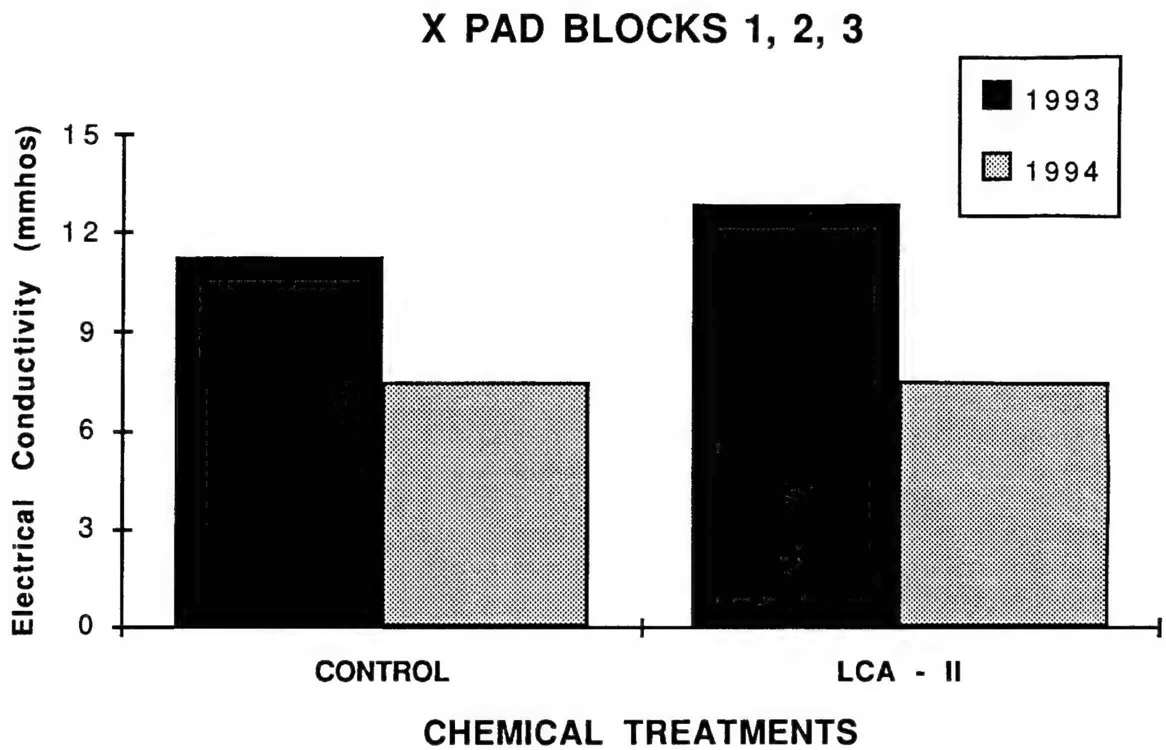
BP EXPLORATION (ALASKA) INC.

X PAD REVEGETATION SITES LOCATION MAP

DATE:	SCALE:	FIGURE:
FEBRUARY 1995	1" = 500'	1

vg12579.dgn

SOIL E. C. LEAST SQUARE MEANS 1993 VS 1994



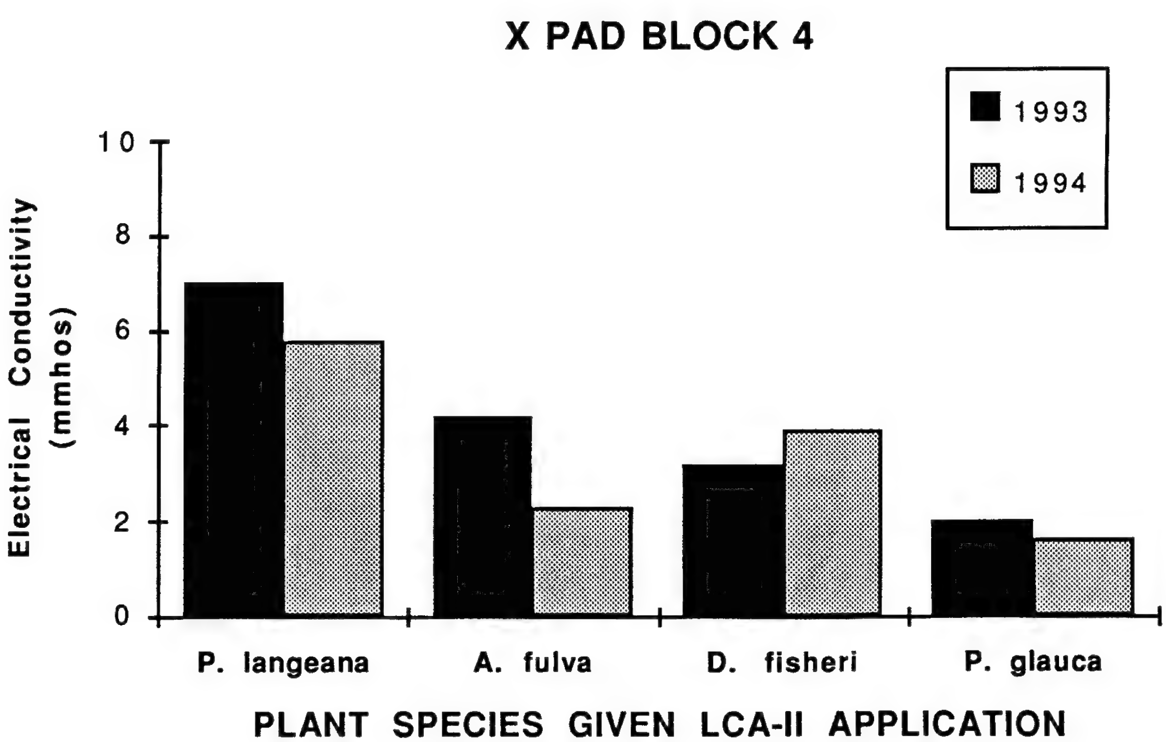


Figure 2

Agroborealis 8:25-29.

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LONG TERM ARCTIC WETLAND REHABILITATION RESEARCH

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Lloyd H. Fanter
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Federal and state permits for North Slope oil development stipulate that sites used for exploration and production operations must eventually be returned to a condition acceptable to the regulating agencies and the landowner, for example, the US Army Corps of Engineers permits. Rehabilitation of abandoned gavel pads and roads used for oil and gas exploration and production is an important issue because compliance standards have not yet been established; permits simply require each site to be rehabilitated to the satisfaction of the permitting agency. It may not be feasible to return gravel to the original mine sites because many of the gravel sites are being converted to overwintering habitat for fish. In consultation with the Corps of Engineers and other Federal and state agencies in Alaska, BP Exploration (Alaska) Inc. (BPX) is researching and testing rehabilitation measures for arctic wetland sites in the North Slope oil fields.

The Put River No. 1 revegetation project, located on one of BPX's early drilling pads in the Prudhoe Bay area, is the first long-term study undertaken on environmental rehabilitation in the Alaskan Arctic. The results from this ten-year study and other studies of wildlife use of disturbed and abandoned sites will be used to evaluate options that enhance the wildlife value of the site while retaining adjacent wetland functions and values. The study will identify native plants which survive on gravel sites and

provide guidelines for optimum conditions for plant establishment and survival. A total of 144 study plots have been established using seed from 33 native plant species. The project will be monitored until 1998 for species composition, percent cover, and the physical and chemical condition of this substrate. Variables being tested on the 144 study plots include gravel thickness, use of overburden, tillage, and grass seeding levels.

Another rehabilitation study is testing the feasibility and several approaches to using Arctophila fulva (arctic pendant grass) to re-establish or increase habitat value in wetlands. In cooperation with the US Fish and Wildlife Service and the Corps of Engineers, BPX has begun a five-year program to evaluate the feasibility of using Arctophila fulva to increase the habitat value of impoundments created by altered drainage patterns from gravel placement in Arctic wetlands. Research efforts at over 100 North Slope sites will help regulators assess how best to rehabilitate wetland habitats. Additional research on wildlife use of natural and man-made gravel sites and impoundments may help determine the usefulness of these sites for wildlife. Results to date indicate that a number of approaches can achieve the ultimate goal of re-establishing or perhaps enhancing wildlife habitat while retaining adjacent wetland functions and values.

Results from these long-term studies will help both permit applicants and regulatory agencies to develop and to evaluate options for Arctic wetlands rehabilitation.

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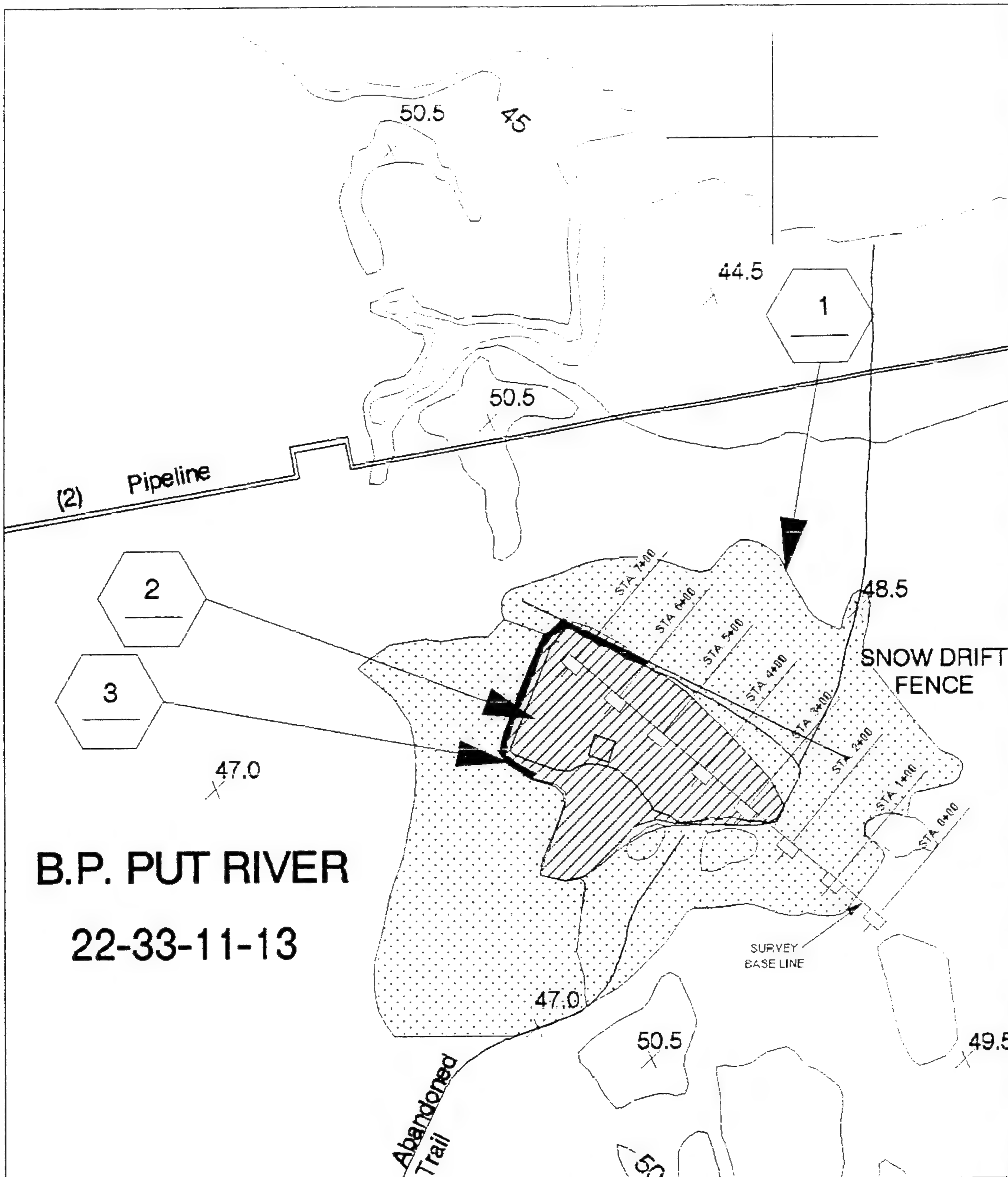


EXPLANATION

- (1) FALL 1988 DORMANT SEEDED AREAS
- (2) GRAVEL REMOVAL SPRING 1989 DORMANT SEEDED AREAS
- (3) MAY 1990 ADDITIONAL GRAVEL REMOVAL, ACTIVE SEEDED JUNE 1990
- PHOTO TEST PLOT, STATION LOCATIONS
- 1988 WELL LOCATION, REMOVED 1989

NOTE
AREA 1 FERTILIZED SEPT 88 & SEPT 89
AREA 2 FERTILIZED MAY 89 & SEPT. 89

Meets Nat. Map Standards for 1" = 300' and smaller

BP EXPLORATION (ALASKA) INC.

B.P. PUT RIVER (22-33-11-13)
REVEGETATION (1988-89)
LOCATION MAP

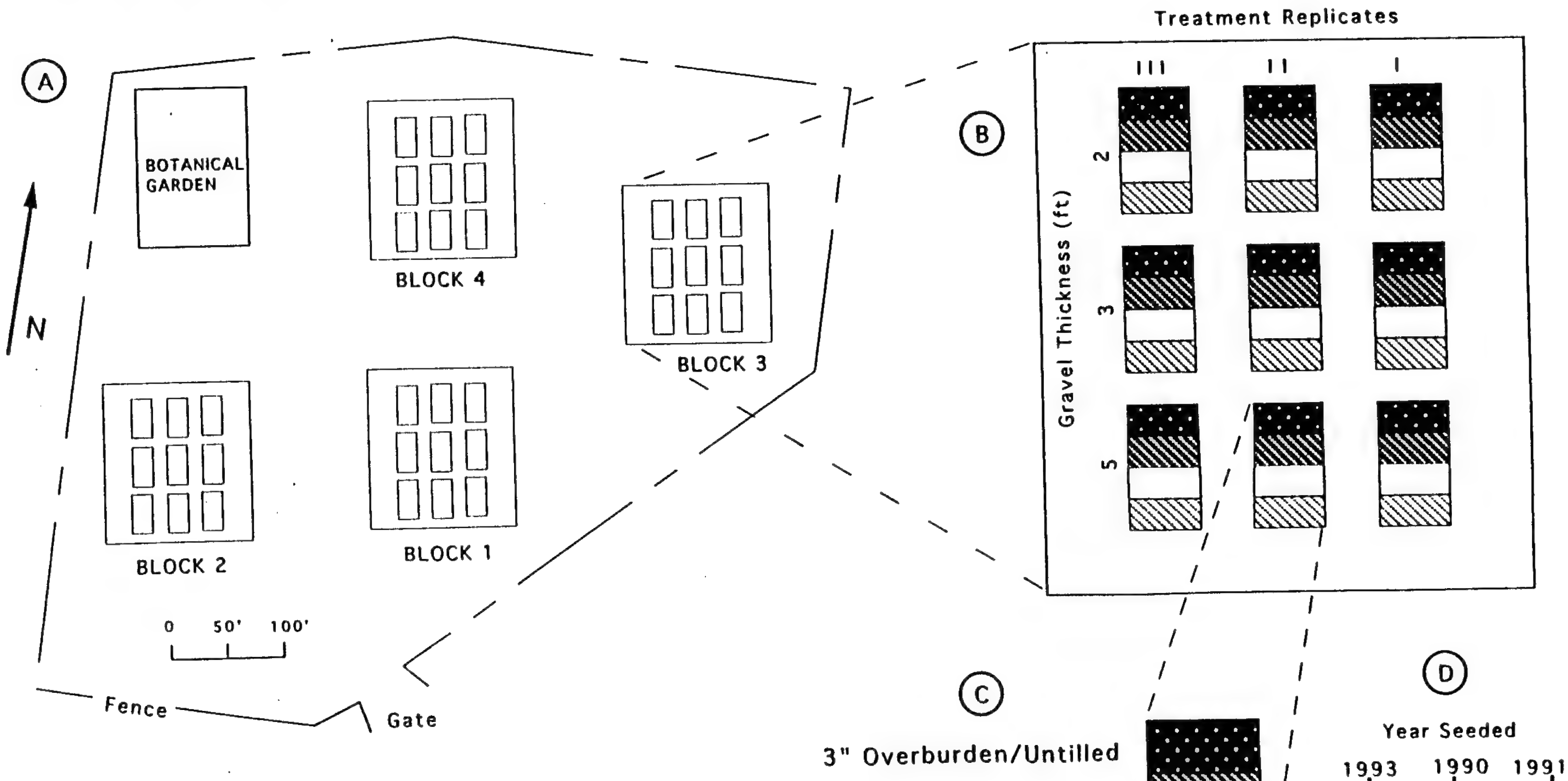
DATE DRAWN	DATE REVISED	CHECKED BY	SCALE	SHEET
12-7-90		SCL / EJK	1" = 250'	2 OF 3

Translated from BPREVEG.DGN

Base Map from 1973 Photography updated 1988

Gravel Vegetation Experiments —

Alaska North Slope



Block 1: Snow Fence/Seeded
Block 2: No Snow Fence/Seeded
Block 3: Snow Fence/Unseeded
Block 4: No Snow Fence/Unseeded

SESSION RE14:

RESTORATION, PROTECTION, AND CREATION: BENEFICIAL USES OF DREDGED MATERIAL

Dr. Mary C. Landin, Chair

PHOSPHORUS CHARACTERISTICS OF CREATED DREDGED MATERIAL MARSHES AS COMPARED TO SIMILARLY AGED NATURAL MARSHES

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Created wetlands generally are not similar to natural wetlands due to their relatively young age. This has led to speculation on how long it will take a created wetland to function as a natural wetland. However, no research has been conducted to determine if created wetlands are similar to comparably aged natural wetlands. The objective of this study was to determine if surface sediments of marshes created from dredged material have phosphorus concentrations similar to those of comparably aged natural marshes in the Atchafalaya River Delta. Delta marshes were split into three age classes, young (1-3 yrs), intermediate (5-10 yrs), and old (15-20 yrs). One created and one natural marsh was chosen from each age class. An additional natural marsh was chosen from the 15-20 yr age class. Where possible, marshes were stratified by elevation (low, mid, and high). Three plots were established within each strata. Soil phosphorus concentrations were determined by chemical extraction of sediment samples (Olsen and Sommers, 1982; APHA, 1985) collected from each plot in November and December of 1993 and in January, May and July of 1994.

Because no seasonal trends in soil phosphorus were apparent, all data for each phosphorus form was combined to obtain overall means (Tables 1 and 2). At mid elevations, old and intermediately aged created marsh sediments had mean phosphorus concentrations which were similar to or greater than mean concentrations in comparable aged natural marsh sediments (Table 1). Except for organic phosphorus, mean phosphorus concentrations in young created marsh sediments tended to be lower than in natural marsh sediments and lower than in other created marsh sediments (Tables 1 and 2). Mean phosphorus concentrations in the old created marsh were similar to mean concentrations in old natural marshes at low elevations but not at high elevations (Table 2). Also in both created and natural old marsh sediments, mean phosphorus concentrations were highest at the high elevation for all phosphorus forms except calcium-bound phosphorus which was lowest

Table 1. Mean concentrations of soil phosphorus (P) forms at mid elevation in natural (N) and created (C) marshes which belong to three different age classes.

Marsh (Age)	Fe, Al-P * ug P/g soil	RS-P ug P/g soil	Ca-P ug P/g soil	Org-P ug P/g soil	Total P ug P/g soil
N (15-20 yrs)	88 (8.7)#	52 (5.0)	303 (7.6)	83 (11.5)	524 (18.5)
C (15-20 yrs)	62 (5.8)	31 (5.4)	316 (8.6)	92 (19.7)	501 (23.4)
N (5-10 yrs)	92 (10.5)	52 (9.5)	252 (9.5)	71 (15.6)	463 (24.2)
C (5-10 yrs)	102 (5.8)	49 (7.7)	241 (6.6)	165 (19.4)	557 (15.2)
N (<1-3 yrs)	85 (6.8)	45 (6.3)	236 (5.3)	65 (10.9)	430 (14.8)
C (<1-3 yrs)	37 (4.3)	17 (4.1)	155 (2.7)	49 (5.3)	258 (8.9)

* Soil phosphorus forms are iron-and aluminum-bound P, reductant-soluble P, calcium-bound P, organic P and total P.

\# Mean with one standard error in parentheses.

Table 2. Mean concentrations of soil phosphorus (P) forms at low and high elevations in natural (N) and created (C) marshes.

Marsh (Age)	Elevation	Fe, Al-P * ug P/g soil	RS-P ug P/g soil	Ca-P ug P/g soil	Org-P ug P/g soil	Total P ug P/g soil
N (15-20 yrs)	Low	103 (4.7)#	60 (7.2)	285 (6.4)	98 (11.0)	543 (11.9)
C (15-20 yrs)	Low	74 (5.3)	44 (5.2)	282 (5.5)	88 (13.1)	489 (16.8)
C (<1-3 yrs)	Low	54 (4.4)	29 (4.8)	176 (5.6)	34 (8.5)	289 (11.3)
N (15-20 yrs)	High	194 (19.4)	111 (14.7)	261 (6.6)	171 (23.7)	737 (43.8)
C (15-20 yrs)	High	107 (7.5)	68 (20.0)	221 (10.1)	174 (22.5)	556 (20.7)
C (<1-3 yrs)	High	35 (4.2)	19 (4.3)	162 (4.0)	34 (7.5)	247 (7.5)

* Soil phosphorus forms are iron-and aluminum-bound P, reductant-soluble P, calcium-bound P, organic P and total P.

\# Mean with one standard error in parentheses.

at the high elevations (Table 2). Calcium-bound phosphorus was the dominant fraction for all sediments accounting for 33% to 67% of the total soil phosphorus (Tables 1 and 2).

These results indicate that in the Atchalalaya Delta, the young created marsh sediments do not have similar phosphorus characteristics as natural marsh sediments. However, sediments from mid elevations in the created marshes do develop phosphorus characteristics which are similar to those of natural marsh sediments after three to five years (Table 1). Adams (1978) found that a two-year-old tidal freshwater marsh created from dredged material had similar total phosphorus concentrations as a nearby natural marsh while Craft et al. (1988) concluded that a saltmarsh created from dredged material would take greater than 15 years to develop similar phosphorus pools as a nearby natural marsh. Results from this study suggest that created marshes in the Atchafalaya Delta develop natural phosphorus characteristics due to sediment deposition during river flooding. This hypothesis is currently being tested.

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CONSTRUCTION OF A DEMONSTRATION MARSH USING LARGE-SCALE CUTTER HEAD DREDGING EQUIPMENT IN GALVESTON BAY, TEXAS

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Abstract

The proposed Houston Ship Channel (HSC) Modernization Project and the Recommended Beneficial Use Disposal Plan (the BUG Plan) for the bay reach of the HSC will entail the removal and disposal of approximately 67,232,000 cubic meters of dredged material over the 50-year life of the project. Approximately 1,720 hectares(ha) of marsh habitat is proposed to be created from the dredged material. To evaluate the technical feasibility of the plan, the Beneficial Uses Group (the BUG) recommended that a large-scale demonstration project be constructed using materials, equipment and techniques that would replicate those that are envisioned for the BUG Plan.

Introduction

The purpose of the Demonstration Marsh Project is to identify essential elements of environmental and engineering design practices and management requirements needed for the establishment, growth, and survival of created marsh. These include identification of the key operating requirements for typical dredging equipment most likely to be utilized for the future placement of new work and maintenance dredged materials for beneficial uses. To this end, the Port of Houston Authority (the PHA) and the U.S. Army Corps of Engineers (the Corps) constructed a 100 ha demonstration site in Upper Galveston Bay.

Project Design

The essential elements of the marsh design for construction are: 1) construction of a hydraulically-placed containment levee using suitable materials such as stiff clays, sand and shell; 2) placement of fill material for marsh substrate typically using fine-grained materials associated with maintenance dredging; and 3) construction of levee protection measures to prevent erosion and protect the marsh interior. Accordingly, numerous types of geotechnical investigations are required to successfully construct these elements in the open waters of Galveston Bay.

Geotechnical Investigations

Subsurface investigations of the HSC in the form of core borings performed by the Corps in 1962, 1963, 1972 and 1992 were analyzed by the Joint Venture for evaluation of the dredgeability, transport, and construction uses of the subsurface material. A large portion of the new work materials were identified as medium to stiff clays, stiff to hard clays, sands, and shell suitable for hydraulic placement of containment levees. Results of this analysis indicated that suitable quantities of levee materials below the channel prism of the HSC were available near the proposed demonstration marsh site. Detailed geotechnical investigations were completed.

Development of Bioengineering Criteria

One approach to designing marshes that function similar to natural marshes is to create marshes with physical attributes (i.e., elevation, geomorphology) that approximate those of existing marshes. It is well established in the scientific literature that physical attributes of marshes influence the distribution of plants and animals. For example, marsh plants tolerate only a narrow elevation range in Galveston Bay. Therefore, to ensure that vegetation established in created marshes is similar to natural marshes, the dredged material must have the approximate elevation range exhibited in nearby existing (reference) marshes.

Design criteria for creating marshes that are similar to natural marshes in Galveston Bay are not widely known. The National Marine Fisheries Service (NMFS) under contract with PHA undertook a study to:

- Characterize existing (reference) marshes near the beneficial use sites by measuring a variety of habitat attributes from aerial photography and in- field surveys;

- Measure and compare various aquatic species usage for different types of habitats present in the reference marshes; and

- Determine which habitat features of the reference marshes should be constructed and tested in the Demonstration Marsh for application to the design of beneficial use sites recommended in the Beneficial Use Disposal Plan.

Results and Summary

Construction of the Demonstration Marsh site has fulfilled its purpose many times over as several key operational, engineering and environmental design elements are being refined and/or developed from construction and monitoring of the site.

The benefits derived from construction of the demonstration marsh are many; some of these are discussed below.

1. Construction of a 100 ha Demonstration Marsh provided the BUG with the opportunity to observe construction, planting, and biological utilization of a created marsh on a scale equivalent to the individual marsh cells proposed in the Beneficial Use Disposal Plan for the HSC Widening and Deepening Project.

2. Refinement of construction techniques for marsh creation, both for levee construction and fill placement, were achieved.

3. Utilization of data obtained from the NMFS survey of natural reference marshes enabled the BUG to develop and implement bioengineering parameters to create a marsh that is functionally equivalent to natural marshes in Galveston Bay.

4. New habitats such as resting, nesting and feeding areas created by the construction of the clay and sand levee and de- watering and consolidation of the fill material have been heavily used by both shorebirds and colonial waterbirds for nesting, resting and feeding.

Future Work Items

To complete development of the Demonstration Marsh, ditching of the site will be carried out to assist the natural shrinkage and consolidation of the fill material to the desired elevation range established by the NMFS survey of natural marshes in the local area. Once the fill area reaches a favorable elevation range, the marsh area will be planted using a planting design developed by the BUG to assist in the development of final plans and specifications for marsh creation proposed in the BUG Plan. Monitoring and evaluation of marsh development will be continued to further the lessons learned to date.

CONSTRUCTION OF A MARSH IN THE LABRANCHE PONDS OF LOUISIANA

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Abstract

This paper describes creation of a marsh in 360 acres of ponds in southeastern Louisiana. This is the first project funded under the Coastal Wetlands Planning, Protection and Restoration Act. Within a year, wildlife usage was high and fishery utilization began. The project will be monitored for 20 years.

The flotant marsh on the south shore of Lake Pontchartrain, Louisiana was part of a plantation, but uncultivated, for many years. From 1905-1910, a land developer bought and drained over 8,000 acres of these wetlands. In September 1915, a hurricane pushed large volumes of water into Lake Pontchartrain and flooded these drained lands.

In 1990, the Corps with its experience in using dredged material to build wetlands, suggested creation of marsh in these ponds as one of the first projects to be funded under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). Even though this project was expensive in terms of cost per habitat unit, the CWPPRA Task Force selected it because they felt it was a showcase project, sure to succeed.

Biologists surveyed adjacent marshes and determined the optimum marsh elevation was from 0.75 to 1.34 feet NGVD. They recommended that the 360-acre area be 70 percent marsh and 30 percent water after five years. Plans called for pumping 2.5 million cubic yards (cy), filling the area to + 4 feet NGVD. Originally, borrow was to have been taken from lake bottoms directly adjacent to the Bonnet Carre Floodway (Figure 1). Analysis showed this material to be heavy sand. The lake bottoms in front of the area were a lighter material, more suitable for marsh creation. The design called for a containment levee around the entire area. Plans provided for the dredged material to flow across the area, dropping its sediment, then exiting nearly devoid of sediment.

T. L. James and Co. Inc. started construction of containment dikes in December 1993, began pumping began in March 1994, and completed their work in early April. They used a much larger dredge than expected, which lowered project costs. However, faster pumping filled the area more rapidly than anticipated and sediment began depositing in a canal outside the marsh creation site. A closure at the southern end of this canal was breached. The sediment filled a deep area in the canal, still within the easement. Due to the loss of this sediment, the contractor had to pump 2.7 million cy. In July 1994, a crop duster dropped 8,000 pounds of Japanese millet seed. The site had a heavy cover of millet by August. For the next 20 years, habitat types, sediments, water elevations, and vegetation will be monitored.

Once the area was vegetated, the CWPPRA Task Force held a news conference. The project got excellent local publicity, including a front page story in the New Orleans paper. High numbers of waterfowl used the site during the winter. By spring, natural ponds and bayous formed within the site and small fish were observed. Wading birds, alligators, nutria and endangered species such as brown pelicans and bald eagles use this marsh. Numerous motorists view the newly-created marsh as they travel I- 10 between Baton Rouge and New Orleans. This project is a true CWPPRA success story.

INNOVATIVE ALTERNATIVE FOR WETLANDS RESTORATION: TRANSPORT AND DISTRIBUTION OF DREDGED MATERIAL BY LARGE HOVERCRAFT

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Abstract

Thin layer placement of dredged material in wetlands areas

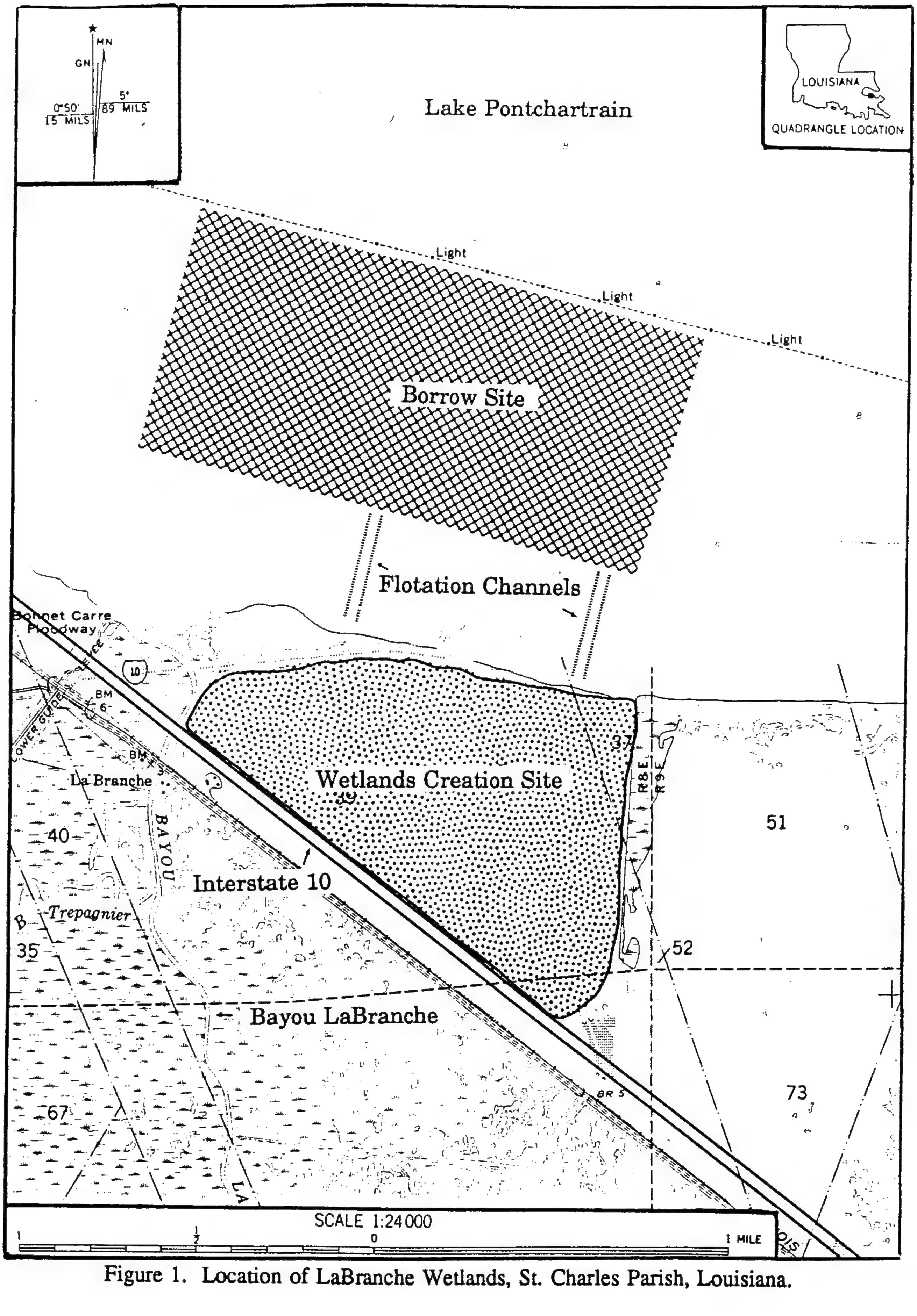

Figure 1. Location of LaBranche Wetlands, St. Charles Parish, Louisiana.

has been proposed as a viable disposal alternative that could address the need for sediment and nutrient resources for deteriorating wetlands. The focus of this study addresses the technical and economic feasibility of a conceptual "hoverbarge" as a transport mechanism for dredged material nourishment of wetlands.

Transport and distribution of dredged material in coastal wetlands is motivated by the need to address severe and ongoing losses due to subsidence and impacts of anthropogenic activities. Hovercraft have been proposed as an environmentally sensitive transport alternative. The scope of the study was constrained by limited available data pertaining to environmental effects of hovercraft traffic on wetlands and lack of actual performance and cost data.

Environmental Effects

Studies of the impact of hovercraft on wetland soils and vegetation are limited but generally seem to indicate that effects are minimal and temporary, except under certain circumstances (Planning Systems Inc. 1984). However, the effects of continuous operation over a restricted area has not been evaluated.

Technical and Economic Feasibility

Technical Feasibility. At the time of this study, a hoverbarge prototype had not been developed. The technical feasibility of hovercraft transport of dredged material into wetlands was evaluated based on identifiable technical issues, status of the current technology, necessary physical and operational modifications, and potential interfaces with dredging operations. The principal technical issues include: load capacity, stability, loading/offloading operations, performance, and environmental considerations.

The load capacity of hovercraft is limited; currently 75 tons maximum domestically. The maximum feasible payload size is projected to be 300 tons, according to industry experts. A 300 ton payload corresponds to a volume of approximately 247 cuyd, depending upon the material and solids concentration, as compared to the 1500 to 4000 cuyd capacities of conventional barges. Interim storage of sediments would be required because typical dredged material production far exceeds foreseeable utilization rates. The stability of hovercraft in transporting bulk cargo is unknown. Trim and balance problems have been reported under certain conditions. Modifications of the craft to address this concern, as well as to facilitate loading, offloading and distribution of materials, would be required. Operating performance in a low speed, high capacity application has not been demonstrated.

Economic Feasibility. The economic analysis of the hoverbarge concept was based on actual capital and operating costs of military

hovercraft, the LCAC and the LACV30, and industry estimates. Because significant differences exist between the proposed hoverbarge prototype existing hovercraft, the cost analysis cannot be considered to be definitive. However, an estimated cost range was established which was compared to pipeline transport, the most economical conventional transport alternative for the volumes and distances projected (Souder, Paul S., Tobias, Leo, Imperial, J.F., Mushal, Frances C. 1978).

Conclusions

From a technical perspective, the hoverbarge concept appears to be viable but the load capacity of hovercraft is limited and the volume of sediments that can be transported is small relative to conventional means of transport. Estimates indicate that due to high capital and operating costs, the use of hovercraft to transport and distribute slurried sediments will be significantly more expensive than other methods available. Environmental justification as a compensating factor has not been adequately demonstrated at this time.

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RESTORATION OF FORESTED HARDWOOD WETLANDS FOLLOWING DREDGE MINING FOR MINERAL SANDS ON RELICT BEACH IN NORTHEAST FLORIDA

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The forested hardwood wetland reclamation site at RGC are reclaimed following dredge mining for mineral sands on relict beach ridged in NE Florida. Wetlands are replaced as "acre for acre" - "type for type" for wetland disturbed by our operation. RGC utilizes extensive detailed surveying during critical stages in wetland site preparation to create appropriate gradients to insure proper hydrology within the site, delineation of appropriate wetland vegetation planting zones and to create microtopography including hammocks within these zones. Additionally, RGC collects seeds from wetland species on-site which are utilized to grow the three gallon nursery stock planting in our sites.

SESSION SM7

STEWARDSHIP AND MANAGEMENT: OTHER MANAGEMENT TECHNOLOGIES I

Ms. Mary J. Flores, Chair

DEVELOPMENT OF A REGIONAL WETLAND PRESERVATION PLAN FOR VERNAL POOLS IN THE SANTA ROSA PLAIN, SONOMA COUNTY, CALIFORNIA

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Vernal pools are seasonal wetlands that are formed in depressions on soils that have either clay or silicate indurated layers. In California, an extremely diverse flora has evolved in association with vernal pools. These areas may represent the most floristically diverse habitats in western North America relative to their aerial coverage and include 69 vernal pool endemic species many of which have federal or state protection under the federal and state Endangered Species Acts. In addition, these areas are diverse with respect to invertebrates, including solitary bees that have co-evolved with some of the vernal pool endemic plant species.

Over the past four decades vernal pool habitats in the Santa Rosa Plain, Sonoma County, California have declined in area due to a combination of more intensive urban development, changes in agriculture from open pasture land used by dairies to intensive land use in the form of vineyards, orchards, and a variety of row crops. As much as 80 percent of the vernal pool and other seasonal wetland habitats may have been lost during the changes in land use over the recent past. Implementation of Clean Water Act for wetland fills and the loss of populations of three species of federally- and state-listed plant species has recently caused a conflict between local land development, City and County Planning Departments, local wastewater agencies, private land owners, farm and agricultural interests with federal and state regulatory agencies. As a result of these conflicts and issues of cumulative impacts to wetlands and wetland dependent resources such as the rare plant species, the San Francisco District of the Corps of Engineers temporarily suspended issuing nationwide 26 permits. This suspension of the nationwide permit created significant controversy, but has lead to the recognition by most parties that a plan could be developed to address the issues.

In order to resolve the conflicts with land use and wetland resources a Vernal Pool Task Force was formed and was composed of federal, state, and local agencies, local development and agricultural interests, and local environmental groups. The Task Force was resolved to develop a Vernal Pool Ecosystem Preservation Plan that would identify areas for wetland and rare species protection, and areas wetland creation, restoration, or enhancement. Further the Plan would develop a regulatory permitting process that would streamline permitting for those proposing to develop in areas that were considered to be low quality wetlands where impacts would to the resources would be minimal.

A contract was awarded to CH2M HILL in April 1994 to work with the Task Force in developing the plan. The Plan included: 1) development of ground rules that the Task Force could operate under to develop consensus of the process, 2) a set of goals and objectives, 3) collection of biological data from existing sources on the wetland resources and rare plant and animal species and develop a conservation strategy for the rare plant populations, 4) describe the existing regulatory environment and how the current regulatory process has not been adequate, 5) describe the historical and existing land use conditions, 6) develop an evaluation criteria of wetland areas and categorize lands in the study area in terms of vernal pool habitat quality, then develop a potential preserve system, 7) identify non- regulatory mechanisms that could potentially be used to preserve vernal pool ecosystem resources, 8) outline a regulatory process that would streamline permitting for low quality areas while achieving specific conservation goals, 9) outline future areas of research needs, regulatory implementation, and establishment of preserves such as through mitigation banks.

RESOURCE MANAGEMENT AND PLANNING FOR CALIFORNIA'S CENTRAL VALLEY GRASSLAND/VERNAL POOL RANGELANDS

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Future growth of the Central Valley's population centers will inevitably result in continued urbanization of rangelands. These grasslands also support shallow seasonal ponds, often called vernal pools, that have been effectively managed by livestock operators for centuries. Since the mid-1980's, vernal pools have been regulated under the Clean Water Act. With the recent listing of the "fairy shrimp", they are now also regulated under the Endangered Species Act. The combined effect of regulation from

different federal and state agencies complicates continued range management, and has resulted in planning and regulatory processes which often have significant economic impacts without corresponding environmental benefits.

Federal regulation under the Clean Water Act (CWA) and the Endangered Species Act (ESA) is a significant concern for agricultural managers and has made local land use planning particularly difficult. The perceived inflexibility of both the CWA and the ESA has caused constant controversy regarding land use decisions. A review of both laws indicates that the flexibility inherent in both can allow for reasonable solutions. In addition, the current Administration has indicated a willingness to return to workable solutions that are based on incentives as opposed to punitive measures.

Vernal pools, considered by resource agencies to be rare until recently, are known to be widespread along the valley's eastern terrace landscapes. Habitat distribution data developed recently for twenty counties indicates significant opportunities for resource management and conservation of the habitat without affecting historic ranching practices.

A case study is presented to model a resource management plan for vernal pool/grassland habitat to use the flexibility available in CWA and ESA policy. In this scenario, mitigation funds from urbanizing areas that have traditionally been applied to on-site solutions can be applied to a management strategy that includes acquisition of conservation easements, mitigation banking, habitat restoration, and habitat enhancement through agricultural management practices. Livestock grazing has proven over centuries to be a sustainable use of California rangelands relative to vernal pools. Ranchers that wish to sell conservation easements can therefore be provided with financial incentives to continue to manage lands for livestock, while preserving desired biodiversity in the grassland/vernal pool landscapes. Economic development within urban planning areas can then proceed without significant delay or the forgone economic opportunity currently associated with preservation of small habitat preserves isolated by urban uses.

This new approach to CWA and ESA mitigation is sound from a conservation standpoint, as it optimizes the use of required mitigation funds to acquire easements and restore habitats, while reducing red tape, maintenance and monitoring costs, and directing financial resources to the historic land stewards who have preserved these rangelands historically.

EVALUATION OF MECHANICAL AND CHEMICAL METHODS FOR CONTROL OF MALALEUCA (MELALEUCA QUINQUENERVIA) IN SOUTHERN FLORIDA, USA

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It has been estimated that melaleuca trees have invaded and occupy thousands of hectares in southern Florida and are spreading to new areas at a rate of about 1,000 ha/ year; stands with as many as 5,000 stems per ha have been reported (DiStefano and Fisher, 1983/1984). Attempts to control mature melaleuca at Lake Okeechobee have resulted in re-establishment of dense stands of seedlings (Stocker, 1982). A factor in the aggressive colonizing ability of this species is that trees are often multistemmed and flower up to three times per year. Numerous flowers are borne on the current season's branch growth, the branches continue to grow and leaves are formed beyond the flowers (Meyers, 1983). Approximately 250 very small seeds may be formed in each closed, woody capsule (Woodall, 1982). Woodall reported that seed release occurs when the moisture supply to the capsule is interrupted by fire, frost, wind, natural pruning or human activities. Alexander and Hofstetter (1975) estimated that a single 10 m tall tree could store over 20 million seeds in its capsules.

Woodall (1983) studied the establishment of melaleuca seedlings in the pine-cypress ecotone of southwest Florida. He found that seeds were long-lived on or in the soil and lost no germination ability after 10 months of shallow burial in a swamp but seeds buried in a well drained area lost two-thirds of their viability in this time span. He also reported that burial prevented germination. Moist to saturated soils for several months, but rarely flooded, provide optimum conditions for tree establishment (Myers, 1983).

The objectives of this study were to determine the effects of selected treatment methods on vegetation regrowth and to assess their results in control of melaleuca. Seven approximately 3.3 ha plots were established near Moore Haven, Florida along the southwest Lake Okeechobee levee road. After mechanical uprooting, stacking and burning all melaleuca trees, the areas were harrowed with a disk. Two plots were treated with Rodeo herbicide, two with Velpar L, one planted with common baldcypress (Taxodium distichum (L.) Richard) and red maple (Acer rubrum L.), one was a control with no further treatment and one had regrowth melaleuca manually removed. One and two years later, results of the these treatments were assessed using transect lines and quadrats. A total of 106 species of plants were found, 90 species each study year were within the quadrats, 16 new in 1993, 16 absent from the 1992 study.

Frequency of species and percent cover increased from 1992 to 1993. Dog- fennel (Eupatorium capillifolium (Lam.)) small and eastern baccharis (Baccharis hamilifolia L.) were cover dominant and most frequent in 1992; these two species were most frequent in 1993 with a variety of species cover dominant. Soil analyses indicated that the control plot differed from the planted and Rodeo herbicide plot in higher percent organic matter and sulfur content. The berm area where the trees were burned was higher in phosphorus and potassium than other areas of the plots. The control plot had the most melaleuca regrowth. The fewest melaleuca trees (3) were counted in the study area of Plot 1, which was not treated with herbicide, it is possible that the 1992 high water level in this plot may have prevented tree regrowth. The highest concentration of Velpar L herbicide treatment plot had 11 trees, the second fewest.

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SELECTIVE CONTROL OF PURPLE LOOSESTRIFE WITH TRICLOPYR

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Purple loosestrife is an invasive plant that threatens

biodiversity of natural wetlands in over 40 states. This exotic species can displace native vegetation through rapid growth and heavy seed production, resulting in monotypic stands that dramatically reduce vegetative diversity, while providing little food or habitat for associated wildlife. Purple loosestrife can establish and thrive in areas where natural and man-made disturbances (including plant control techniques) eliminate native wetland plant communities. Use of conventional, non- chemical management techniques, e.g., flooding, draining, cutting, burning, are inherently non-selective and seldom result in long- term control of purple loosestrife infestations. Approved herbicides offer a selective technique for reducing purple loosestrife levels, eradicating pioneer colonies of the plant, and restoring native wetland communities. The objectives of this study were to evaluate effectiveness of the herbicide triclopyr on purple loosestrife, and to monitor changes in the associated wetland plant community following triclopyr treatment. This research resulted in a chemical technique for controlling purple loosestrife in wetland communities that includes minimizing damage to non-target plants, particularly monocots, while offering a potential for restoring a diverse plant community. Results from this work will be used to provide initial guidance for the selective control of purple loosestrife using triclopyr. Data will also be used to support the National aquatic registration of that herbicide.

INCORPORATING ECOLOGICAL MOSQUITO CONTROL INTO MANAGED WETLANDS

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Abstract

As a natural component of wetland ecosystems, mosquitoes can become a perceived or a real public annoyance/public health problem. A lack of understanding and communication between wetlands biologists and mosquito abatement personnel has sometimes led to a polarization of viewpoints on the wisdom of wetland mitigation (especially in urban areas) and on proper wetlands management techniques. We propose that an understanding of mosquito biology and use of available control technologies can help wetlands managers minimize mosquito annoyance and mosquito- borne disease threats. A brief overview of the varied life cycles of several important Midwestern mosquito species will be integrated into a discussion of wetland design and management techniques for minimizing mosquito production potential. The informed use of bio-rational mosquito control agents such as insect growth

regulators and pesticidal pathogens will be discussed. Information on mosquito abatement programs in the Midwest and contacts for further information on integrated mosquito management within wetlands will be provided.

Introduction

Wetlands pose many dichotomies and paradoxes both technically and politically. Herein lies one person's attraction to them and another's aversion. One question is this.... Are wetlands breeding sites for disease vectors or sublime ecosystems providing a myriad of benefits to humans? The answer can sometimes be both, but, of course, we would prefer to maximize benefits while minimizing health risks. This is phenomenon helps explain why the governmental policy pendulum has swung from subsidizing the draining and filling of wetlands to encouraging their preservation and restoration.

Let's take a short walk through history. Up through the 1920s in the Carbondale, Illinois' area (Jackson County), there were over 2,500 cases of malaria a year that resulted in 50 to 100 deaths. In response to this health threat, a multi-agency campaign drained 60 acres of swamps and ponds, lowered a lake to provide a clear water edge, regraded 45 miles of streams, oiled natural breeding sites, stocked ponds and open wells with top minnows, and conducted extensive inspections and educational measures. The resulting number of malaria cases dropped the following year to 19.

Today, the policies of no net loss and preferred on-site mitigation force the issue of creating wetlands in relatively dense human population areas. Various perspectives arise from the history of human relationships to wetlands. Some people would like to see a revival of presettlement acreage of wetlands, while others decry any creation of wetlands.

We propose an understanding and coordination that deals with the reality of the need to conserve wetland resources while considering disease and mosquito annoyance concerns. Many such efforts are occurring between mosquito control practitioners and wetland managers. For the purpose of focus, we center our discussion on conditions in the Midwest. The situations where it is most important to consider mosquito control design features are in the creation of mitigative wetlands in urbanizing settings. Another sensitive area can include zones of higher horse populations because of concerns with equine encephalitis. The development of ecologically responsible, least-toxic mosquito control techniques requires the identification of target species, an understanding of their natural history, and their vector potential.

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Table 1
Ecological Management Summary
for Control of Mosquitoes*

Taxon	Primary Health Concern	Habitat Requirements	Life Cycle	Targeted Management
Aedes/Psorophora	Aggressive human biters, no major viruses	Flood pools and other temporary water sources. Often in urban settings	Female lay eggs on detritus, in cracks in soils above high water level. Eggs hatch in water with low dissolved oxygen.	• Maximize flow through • Minimize soil-exposing drawdowns during times of high adult mosquito populations • Raise water levels • Maximize oxygenation
Woodland Aedes	*A. triseriatus* is vector of LaCrosse Encephalitis virus	Seasonal woodland pools, tree holes, and artificial containers	Females lay eggs on leaf litter and other periodically-inundated detritus. Small mammals are hosts.	• Eliminate incidental water containers. Not a threat in typical created wetland • Use BTI early in spring on ephemeral pools
Culex pipiens	St. Louis Encephalitis virus	Any waters high in organic matter	Female lay egg rafts on water surface. larvae are mostly bottom feeders. Adults prefer avian hosts.	• Reduce nutrient inputs • Discourage wading bird hosts • Cover water surface with floating plants
Coquillettidia perturbans	Eastern Equine Encephalitis virus	Vascular aquatic plants Abundant in freshwater marshes around Great Lakes	Eggs on underside of floating leaves. Larvae and pupae use plant stems as sources of oxygen. Avian and mammalian hosts.	• Drawdowns early in season strand larvae on plants (thrive in constant water level) • Manage vegetation (reduce/eliminate cattails)
Anopheles ssp.	Malaria	Cleaner, sunlit waters with some floating vegetation Good water quality	Eggs laid singly on water surface Larvae are surface feeders	• Drawdowns strand larvae and expose them to increased wave action and predators • Maximize windfetch, but shade water where possible • BTI not as effective use methoprene

*Characterization and integrated control of specific problems requires the assistance of a mosquito control professional.

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SESSION CW3

CONSTRUCTED WETLANDS: MINING OPERATIONS

Tommy E. Myers, Chair

OVERVIEW OF WETLANDS RESEARCH AT THE TENNESSEE VALLEY AUTHORITY CONSTRUCTED WETLANDS RESEARCH FACILITY

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The Tennessee Valley Authority has constructed a wetlands research facility that was completed in 1992 in Muscle Shoals, AL. The facility consists of a greenhouse, laboratory/office complex, and 32 outdoor mesocosm research cells. Research over the last two years consisted of quantifying plant oxygen transport and nitrogen and phosphorus removal in domestic wastewater. Research is also being conducted on the potential to improve nitrogen by reciprocating water from one wetland cell to another to improve oxygen transport. Future research at the facility will involve remediation of acid mine drainage. A greenhouse study has been initiated to quantify Mn, Cu, Zn, Pb, and Ni removal in acid mine drainage in successive anaerobic and aerobic wetlands.

WETLAND TREATMENT OF MINE DRAINAGE

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Drainage from a mine in northeastern Minnesota contains elevated concentrations of copper, nickel, cobalt, and zinc. A test program was devised to investigate the feasibility of using wetlands to remove the metals from the drainage. Four test plots were built to determine the effect of water level, contact time, vegetation, and surface alterations on metal removal. Optimum removal occurred with low water levels (<5 cm), long contact times (.48 hours), and with a surface amendment of peat and a peat screening material generated as a by-product of commercial peat harvesting. Nickel, which is the major contaminant in the drainage, was generally reduced from 1-2 mg/L to around 0.2 mg/L.

Based on the pilot scale results, 2 full scale treatment systems were built. These systems cover 1.5 to 3 acres and have been in operation since 1992. Although these systems have been successful in removing about 90% of the nickel, only one of the systems has been in complete compliance with NPDES permit requirements. In 1993 and 1994, changes were made to the systems which was not in compliance. The hydraulic gradient was reduced and flow was dispersed. Treatment efficiency has improved, and in 1994, nickel concentrations in the outflow decreased by over 50%, and the system has generally met water quality standards.

SEDIMENT ACCUMULATION RATES IN TVA CONSTRUCTED ACID DRAINAGE TREATMENT WETLANDS AND THE IMPLICATION ON SYSTEM LONGEVITY

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Introduction

The Tennessee Valley Authority is using constructed wetlands to treat acid mine drainage (AMD) at abandoned coal mines in northeastern Alabama. During AMD treatment Fe and Mn oxyhydroxides form a floc sediment layer on the wetland bottom. Little research exists on the long term processing capacity of AMD wetlands. Intuitively, the capacity for retaining this metal floc sediment layer is finite. This study estimates floc accumulation rates and predicts long term capacity for three TVA AMD treatment wetland systems.

Site Descriptions

Wetland systems Impoundment 1 (IMP 1), Impoundment 4 (IMP 4) and Rocky Top 2 (RT 2) were investigated. The three systems are similar in design but vary in water parameters. IMP 1, a four-cell system, collects seepage below an old slurry pond. IMP 4, a three cell system, collects seepage from a reclaimed slurry pond with a pretreatment anoxic limestone drain. RT 2 collects seepage from a reclaimed strip mine. It consists of a pond followed by two wetland cells. Water parameters are described in Table 1.

Table 1. Wetland Characteristics and Water Quality Summary

Wetland System	Age (yrs)	Area (m^2)	Influent Water Parameters (mg/L) pH	Fe	Mn	TSS	Flow (gal/min)
IMP 1	10	5627	6.1	69	9.0	10	13
IMP 4	10	1984	6.5	20	7.0	35	5
RT 2	8	3562*	5.7	45	13	-	68

* does not include pond

Methods and Materials

Each wetland cell was sampled using a 6.1 sqm (20 sq.ft.) grid. Sediment samples and water column depth measurements were taken at each node of the grid. Sediment consists of two visually distinct floc layers. Fe and Mn oxyhydroxide precipitates form a loose "fluffy" floc (FF) layer on the sediment layer surface. Subsequent precipitation causes the layers to de-water forming a compacted floc (CF) layer, representing the long term sediment volume. Sediment samples were visually characterized for metal floc layer depths and selected samples were analyzed chemically for total Fe and Mn (mg/Kg), % total residue in sediment and % volatile residue in sediment.

The compaction rate of the fluffy layer is unknown. This study assumed a conservative one-year compaction rate. Samples were collected June - August 1993. In summer 1993 northern Alabama received a significant decrease in average annual rainfall. In 1993 average rainfall was 38.4 in./yr. compared to 1988-1993 average of 63 in./yr.

Discussion

For each wetland system cell, volumes and accumulation rates of floc, wetland cell volume remaining and operative years remaining were calculated for each wetland system cell (Table 2.).

Table 2. Wetland Cell Floc Accumulation Rates

Wetland System	Area (m^2)	CF Volume (m^3) [a]	FF Volume (m^3)[a]	CF Accumulation Rate (m^3/yr) [b]	FF Accumulation Rate (m^3/yr) [c]	Wetland Cell Volume Remaining [d]	Operative years Remaining [e]
IMP 1							
Cell 1*	2267	18.2	28.36	2.0	28.4	248.7	8
Cell 2	850	9.1	12.3	1.0	12.3	79.5	6
Cell 3	1093	15.6	17.1	1.7	17.1	1 50.7	8
Cell 4	1417	11.2	10.2	1.2	10.2	58.8	5
IMP 4							
Cell 1*	850	13.7	13.6	1.5	13.6	63.3	4
Cell 2	567	17.6	5.9	1.9	5.9	16.5	2
Cell 3	567	25.0	13.9	2.8	13.9	20.7	7
RT 2							
Cell 2*	890	51.9	9.9	7.4	9.9	473.1	27
Cell 3	2672	76.1	91.2	10.9	91.2	1292.7	13

* Influent cell

[a] Compacted and Fluffy Floc Volume based on the following equation: m^3 = [Sum of (X m of floc/sample) x 11.33 m^2]

[b] Compacted Floc Accumulation Rate = Total Compacted Floc Volume in cell / Age - 1 year

[c] Fluffy Floc Accumulation Rate = Total Fluffy Floc Volume in Cell / 1 year

[d] Wetland Cell Volume Remaining (m^3) = [Sum of X m of water column per sample x 11.33 m^2 + Fluffy Floc Volume/Cell]

[e] Operative Years Remaining =[Wetland cell Volume Remaining / (Compacted Floc Accumulation Rate + Fluffy Floc Accumulation Rate)]

As anticipated, excepting cell 3, IMP 1 CF and FF volume decreased in successive cells. In IMP 1, Cell 3 has an additional AMD seep that may explain the higher floc volumes. IMP4 and RT 2 cells showed successive increases in CF volume. NaOH was used at IMP4 Cell 1 outflow until 1990. The slow settling characteristics of the NaOH may explain the higher floc volumes in Cell 2 and 3. 0 During sample collection, Cell 2 was also relatively dry resulting in decreased FF volume. The significant size difference between RT 2 Cell 2 and 3, 890 and 2672 sqm respectively, also contributes to the difference between floc volumes. RT2 Cell 2's low retention time decrease floc formation and settling.

Average operative years remaining are conservative based on the estimated one year FF compaction rate and the low measured water surface elevations due to the drought. The only non-conservative factor in the longevity estimates is scouring. Before cells exceed calculated retention capacity, storm events will potentially cause scouring of the floc. However, other studies have shown vegetation acts as a velocity dissipater stabilizing sediments during storm events (Taylor, 1991).

Conclusion

By directly measuring floc volumes accumulated over a ten year period, this study has demonstrated a tool for predicting the effective longevity of AMD wetlands. Studies have shown that the potency of AMD decreases after 25 years (Brodie, 1995). Current TVA design methods appear to produce systems that last for 20-30 years, yielding adequate system life.

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CREATING WETLANDS ON LANDS DISTURBED BY IRON MINING

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The Mesabi Iron Range, located in northern Minnesota, produces about two thirds of the nation's iron ore. Much of this area is covered by shrub and forested wetland. Since the iron mines typically disturb thousands of acres, it is inevitable that large acres of wetlands are disturbed. Legislation, both state and federal, requires that any wetland disturbed as a result of mining be replaced.

In order to develop an approach to replace these wetlands, a survey of wetlands that have developed on mining lands was conducted. These wetlands were not planned but developed "incidental" to the mining process. Twenty seven wetlands were surveyed and over 50% of these were located on tailings, which are the finely ground waste product produced by the ore processing. Tailings basins cover thousands of acres, and at the completion of mining, could provide an area for wetland creation.

Tailings are comprised of fine silt and clay sized particles, have a pH of around 8.0, and are low in organic matter and nutrients. Despite these characteristics, wetlands did develop in these areas, although vegetation density and diversity was lower than nearby natural wetlands. Vegetation density and diversity in the tailings wetlands, increased during the first 10 years and increased with decreasing distance to natural wetlands.

A series of small test plots (100 square feet) and 1/2 acre demonstration plots were built in two tailings basins in the fall of 1994 to examine: the amount of watershed needed to support a wetland; and the effect of soil amendments, seed mix, and water level on the vegetation type, density, and diversity.

SESSION FA2

ASSESSING WETLAND FUNCTIONS: REGIONAL APPROACHES
R. Daniel Smith, Chair

A GIS-BASED LANDSCAPE SCALE WETLAND FUNCTIONAL ASSESSMENT PROCEDURE

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As part of a wetlands conservation plan for the North Carolina coastal area, the NC Division of Coastal Management has developed a GIS-based wetland functional assessment procedure. The assessment is based on watershed analysis and divides wetlands into both hydrogeomorphic and vegetative cover classes. Functional parameters include wetland type, size, soil characteristics, landscape position, water sources, land uses, and landscape patterns. Parameters are combined to assess the wetland's relatively significance in performing water quality, hydrology, and habitat functions and in contributing to watershed quality. Unlike site-based methods, the procedure allows functional assessment of wetlands over large geographic regions for planning purposes.

WETLAND FUNCTIONS AND VALUES: A DESCRIPTIVE APPROACH

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Abbreviated Paper

For some years now the Regulatory Division of the US Army Corps of Engineers, New England Division (NED), has recognized the limitations of wetland assessment methodologies that generate numerical weightings, rankings and/or averaging of dissimilar wetland functions, which thus unnecessarily bias a project

reviewer. For many of these local or national methods the base data is not reported, and it is thus difficult for the reviewer to reconstruct the indicators that were considered to predict the functions of a wetland. This is because the output is conclusive and not descriptive, As a result, NED advocates an approach that includes a qualitative description of the physical characteristics of the wetlands, including the principal functions and values exhibited, and most importantly the basis for the conclusions using "best professional judgment". All readily available data are presented to an interdisciplinary team for evaluation and consensus recommendations to the Corps decisionmaker.

There was an initial concern by applicants and consultants that this approach to wetland evaluation would be unorganized, unpredictable, not legally defensible and difficult to document, In response, NED developed a format to collect and display this information. The format includes a summary wetland evaluation form and backup reference attachments. (Refer to the attached figures and table.) The completed form typically provides the Corps with sufficient wetland information on a single page needed to make permit decisions (i.e. selection of least damaging alternatives, mitigation goals, significance, etc.).

One key advantage of the method is flexibility in terms of documented rationale to predict the occurrence of various functions . This supports the use of best professional judgment. The approach can be used with varying degrees of information (i.e., office vs. field data). The reviewer can easily recover the source of information used to predict the occurrence of a function and/or value. This approach has been used by NED for numerous projects for several years with positive results. In addition, it was well received by the federal resource agencies. The process is not time consuming and averages 1-2 hours per site. NED is currently preparing an informational color booklet that describes this method in detail and illustrates ways to graphically display wetland information to further aid in the regulatory decision making process.

Acknowledgments

We are pleased to acknowledge the efforts of several individuals who have made significant contributions towards the development of the New England (NED) Wetland Evaluation "Descriptive Approach." Lynn Clements, Michael Sheehan and Kevin Slattery offered valuable technical assistance both in the field and in the development of the evaluation form. William F. Lawless, Chief, NED Regulatory Division, Operations Directorate, developed the wetland evaluation guidance from which the approach originated. Torger Erickson, whose skill with Computer Aided Drafting and Design and Geographic Information Systems was a vital contribution to the graphical representation of statistical application of this wetland evaluation. Both Tina Mah and Mark McInerney provided the

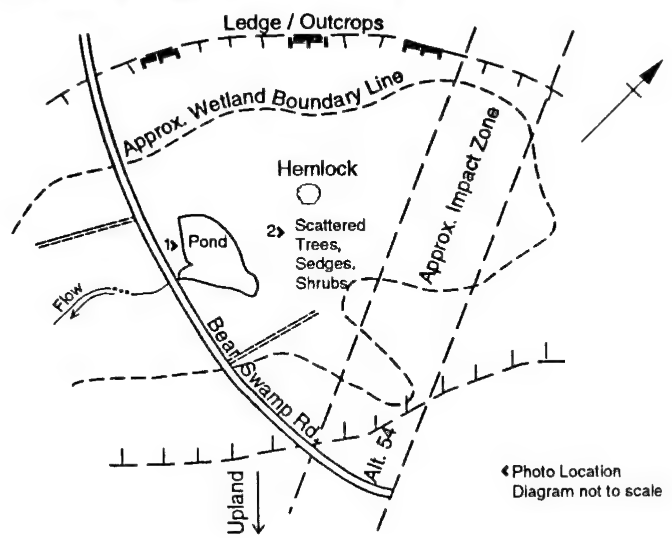
Species List WD1-1
Vegetative

Common Name	Scientific Name
Slippery Elm	Ulmus rubra
Yellow Birch	Betula lutea
Poplar	Populus sp.
White Oak	Quercus alba
Shagbark Hickory	Carya ovata
Grey Birch	Betula populifolia
Ash	Fraxinus sp.
Speckled Alder	Alnus rugos
American Hornbeam	Carpinus caroliniana
American Hop Hornbeam	Ostrya virginiana
Winterberry	Ilex verticillata
Maleberry	Lyonia ligustrina
Hazelnut	Corylus americana
Highbush Blueberry	Vaccinium corymbosum
Sweet Pepperbush	Clethra alnifolia
Azalea	Rhododendron sp.
Dogwood	Cornus sp.
Sensitive Fern	Onoclea sensibilis
Cattail	Typha latifolia
Meadowsweet	Spiraea latifolia
Sphagnum Moss	Sphagnum sp.
Skunk Cabbage	Symplocarpus foetidus

Wildlife

Common Name	Scientific Name
Blue Jay	Cyanocitta cristata
White-tailed Deer	Odocoileus virginianus
Muskrat	Ondatra zibethicus
Raccoon	Procyon lotor
Black-capped Chickadee	Parus atricapillus
Tufted Titmouse	Parus bicolor
American Goldfinch	Cardeulis tristis

WD1-1 Vegetation and wildlife species list



Photographs of WD1-1 wetland

Wetland Function-Value Evaluation Form

Total area of wetland 11.3ac. Human made? No Is wetland part of a wildlife corridor? Yes or a "habitat island"? No

Adjacent land use Forest, Residential Distance to nearest roadway or other development 0'

Dominant wetland systems present POWH, PFO1E Contingguous undeveloped buffer zone present No

Is the wetland a separate hydraulic system? No If not, where does the wetland lie in the drainage basin? Mid

How many tributaries contribute to the wetland? 1 Wildlife & vegetation diversity/abundance (see attached list)

Wetland I.D. WD1-1
Latitude 41°44'54.86 Longitude 41°44'54.86
Prepared by: LDC, JCL Date 12-7-92
Wetland Impact:
Type Fill Area 4.9 AC

Evaluation based on:
Office ✓ Field ✓
Corps manual wetland delineation completed? Y ✓ N

Function	Occurence Y	Occurence N	Rationale (Reference #)*	Principal Function(s) & Value(s)	Comments
Groundwater Recharge/Discharge	X		2,6,7,9,10,11,12,13		A layer of organic soil blankets the thin glacial till overburden in this area. this wetland is an expression of groundwater discharge.
Floodflow Alteration	~~X~~	X	~~2,5,6,7,8,9,11,13,14~~		Water flow constricted by culvert, some detention occurring in this ponded, well-saturated area. Portion of wetland at imapct area does not store floodwater.
Educational Scientific Value		X	2,3,5,8,9,10,11,12,13		Potential for pond study to occur. No known educational use.
Sediment/Toxicant Retention	X		3,4,5,6,7,8,9,10,12		Sediments can drop out in the ponded section.
Nutrient Removal	X		2,3,5-13		Potential for sediment and nutrient removal exists, logging activities have occurred adjacent to wetland.
Production Export		X	1,2,4,5,6,7,9,10,12,14		Outflow is constricted, little transport occurs via wildlife, wetland is predominantly attenuating nutrients.
Sediment/Shoreline Stabilization		X	4,6,9,10,12,13,14,15		Low flow velocities.
Wildlife Habitat	X		1,2,4,5,6,7,8,(13),16,17, 18,19,21	X	Except for minor road, this wetland is well buffered, and directly connected to the Hop River. Good amphibian habitat.
Recreation		X	2,4,5,6,8,9,10		Wetland is easily accessible, and has some potential to function as educational and recreational area.
Fish and Shellfish Habitat		X	1,5,(6),9,10,14,15,16,17		Culvert restricts access, wetland is relatively small, fisheries site #15.
Uniqueness/Heritage	X	~~X~~	7,(14),17,18,20,22,29	X	Prehistoric archaelogic sensitive sites adjacent to wetlands. Archaelogic artifacts found adjacent to wetland by local archeologist.
Visual Quality/Aesthetics	X		1,2,3,4,5,6,7,8,9,10,11,12		Direct view of wetland exists from roadway. Open water contrasts with surrounding forest land.
ES Endangered Species Habitat		X	None		None found or known to occur here.
Other					

Notes: Additional vegetative species noted at 3/24/93 Wetland Delineation field visit (Refer to Wetland Delineation Form). Phase II wetland assessment is relatively indicative of functions present at impact area.

graphic art work integral to portraying the results of this approach. We also gratefully acknowledge the administrative and technical staffs of the Departments of Transportation of New Hampshire and Connecticut for providing the opportunities to develop ideas and to acquire experience which this paper reflects, as well as review input. Responsibility for any errors which may remain in this paper are the authors' alone.

References

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RAPID ASSESSMENT OF VERNAL POOL FLORISTICS

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Vernal pools are depressional wetlands in California grasslands that are inundated during winter and spring but are dry the remainder of the year. These wetlands support a flora that includes many endemic species (Whitney et al., 1994), unusual in a grassland community dominated by non-native species. Fill of vernal pools has been regulated under the Clean Water Act since 1985, and mitigation for fill typically requires construction of new vernal pool habitat.

In constructing and monitoring over 900 vernal pools in the Sacramento, California region, Sugnet & Associates has worked to develop vernal pool monitoring methods that are efficient, yield meaningful data and analysis, and accurately reflect habitat quality. The Vernal Pool Floristic Index (VPFI), a measure based on floristic quality, was developed by Sugnet & Associates to assess vernal pool function. This index measures the contribution

of known vernal pool species to the overall species composition of vernal pools. The VPFI yields a ranking of wetlands that reflects floristic gradients (and the underlying hydrologic gradients) consistent with other analytic methods.

Calculation of the Vernal Pool Floristic Index

The vernal pool floristic index was modeled after Jaccard's Index, a commonly used similarity index. Using Jaccard's Index with species richness data yields values ranging from zero to one, reflecting the proportion of common species between the two samples. The VPFI compares the species richness of an individual vernal pool against a rule-based list of known vernal pool species, the Vernal Pool Species List (VPSL). The VPFI is calculated as follows:

$$VPFI = \frac{a}{a+b}$$

where "a" equals the number of species occurring in a vernal pool that are on the Vernal Pool Species List, and "b" equals the number of species occurring in a vernal pool that are not on the VPSL. As with Jaccard's Index, VPFI values range from zero to one. VPFI represents the proportion of wetland species found in a vernal pool that are known to occur in that habitat. VPFI values of 0.6 or greater are judged to represent a "successful" vernal pool.

A species is included on the VPSL if it:

1. Is listed as or meets the criteria of a FAC, FACW, or OBL species in the "National List"; AND

2. It meets any one of the following conditions;

   a. It is reported as occurring in vernal pools in the refereed literature; OR

   b. It has been collected or observed in vernal pools; OR

   c. It has been reported as occurring in vernal pools in a regional or state-wide flora.

Comparison to Prevalence Index

Figure 1 is a scatter diagram comparing VPFI and Prevalence Index (PI) values for 520 reference (naturally occurring) vernal pools, while Figure 2 presents a similar comparison for 841 constructed vernal pools. These graphs demonstrate that the species richness-based VPFI closely approximates the variation demonstrated by the species abundance-based PI. Alone, the VPFI offers a method for rapid assessment of vernal pool quality.

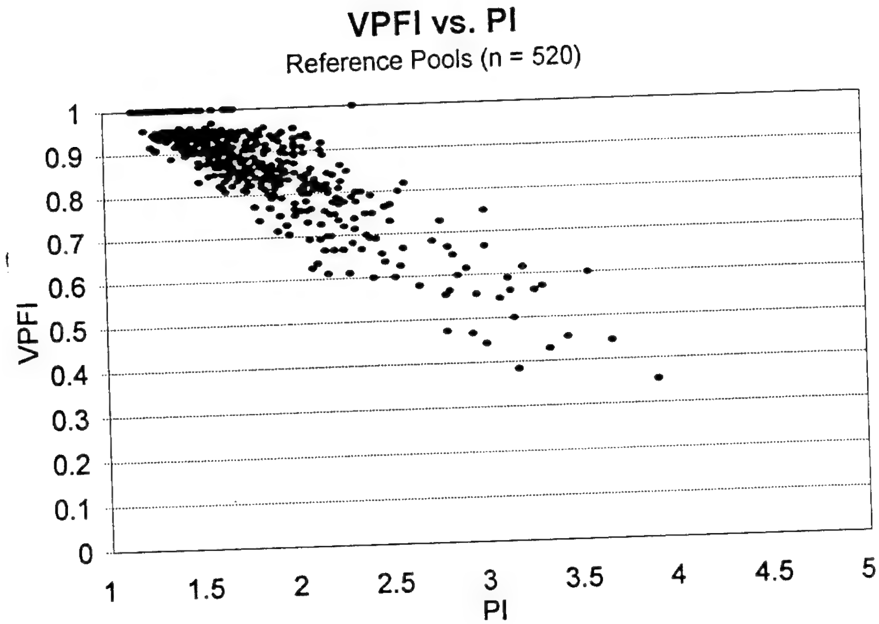

Figure 1

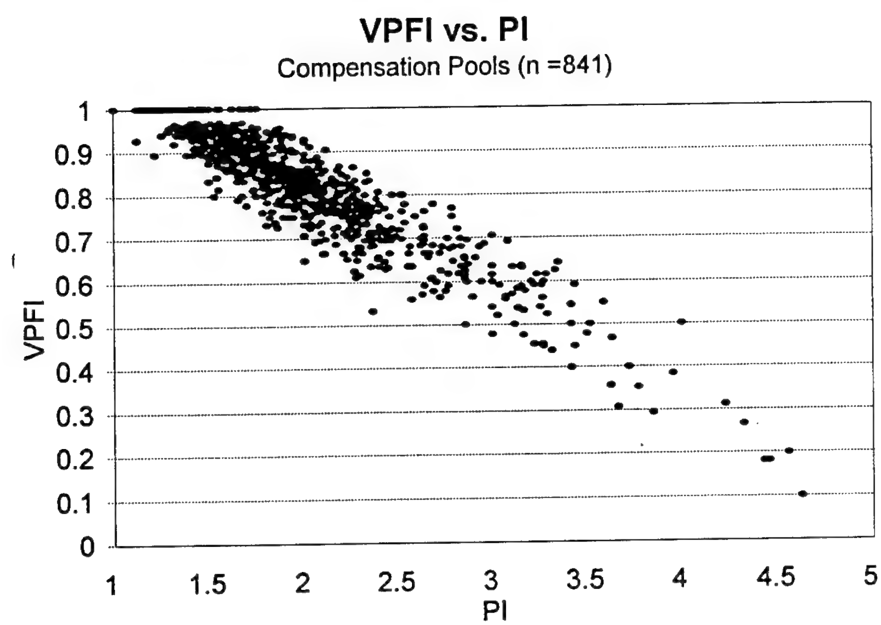

Figure 2

Combined with the use of Prevalence Index and other measures, the VPFI is an important component of a suite of constructed vernal pool performance measurements.

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Whitney, K., Glazner, J., and P. Sugnet. 1994. Vascular plant frequency and dominance in constructed and historic vernal pools. In: Western Wetlands -- Selected Proceedings of the 1993 Conference of the Society of Wetlands Scientists, Western Chapter. D. Kent and J. Zentner, eds.

THE WISCONSIN DNR RAPID ASSESSMENT METHODOLOGY: A SIMPLE QUALITATIVE APPROACH FOR ASSESSING WETLAND FUNCTIONAL VALUES

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The Wisconsin DNR developed and is using a rapid assessment technique for making qualitative evaluations of wetland functional values and decisions about the significance of wetland impacts. In 1991, Wisconsin adopted Wetland Water Quality Standards, which created a definitive process for making decisions regarding projects that affect wetlands. Each year the agency makes permit and water quality certification (under section 401 of the Clean Water Act) decisions on over 500 projects. In most cases staff do not have the time to collect necessary data and implement extensive wetland evaluation models/methodologies. Our goal was to develop a simple, time- efficient methodology that is defensible (both legally and scientifically) and can be completed after limited site visits.

The Rapid Assessment Methodology is a field checklist that requires investigators to focus on important indicator attributes of the wetland and watershed. The methodology takes the form of a field checklist that provides space to document a complete field visit. Some users, including consultants who provide reports to the Department, have employed an electronic version of the checklist that makes for a very concise report format. The evaluator can document location information, wetland type, seasonal conditions, hydrologic setting, soils, vegetation communities and surrounding land-uses in the watershed. The functional value assessment portion requires the evaluator to examine site conditions that provide evidence that a given function is present and to assess the significance of the wetland to perform those functions. The methodology looks at the following functional values:

- Special Features (located in or near state natural areas, state parks, wild and scenic rivers, etc.)
- Floral Diversity
- Wildlife and Fishery Habitat
- Flood and Stormwater Storage/Attenuation
- Water Quality Protection
- Shoreline Protection
- Groundwater Recharge and Discharge
- Aesthetics/Recreation/Education and Science

Positive answers to questions indicate the presence of factors important for the function. The questions are not definitive or exhaustive and are only provided to guide the evaluation. That is, the methodology recognizes that not all wetlands will perform all functions, and thus the evaluator need not be constrained by the questions on the checklist. This flexibility allows the input of new research findings in wetland science into decisions without the need for alterations to a model. For certain functions, the checklist may indicate a need for more in-depth study to make an evaluation. After completing each section, the evaluator should consider the factors observed and use best professional judgment to rate the significance (exceptional, high, medium, low or not applicable) of the wetland for a given function. The result is a listing of the important wetland functional values and documentation of the landscape features that led the evaluator to that decision.

We have shared our simple checklist with neighboring states and several agencies in foreign countries. In the next year we plan to work with the International Crane Foundation to develop an educational tool that uses the checklist to show how the wetland characteristics and the nature of the surrounding watershed are important for understanding the importance of a given wetland system. The Rapid Assessment Methodology has proved very useful and usable for field staff.

SESSION MB4

MITIGATION AND MITIGATION BANKING: LEGAL AND REGULATORY

Robert W. Brumbaugh, Chair

AN OVERVIEW OF LEGAL AND REGULATORY ISSUES IN WETLAND MITIGATION BANKING

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Mitigation banking is a recognized part of the Clean Water Act is section 404 permit process. It offers a mechanism to ensure that the totality of environmental costs of activities detrimental to wetlands are offset. Basic public and private mitigation banking concepts have been developed and a few banks exist. While there are some difficulties in quantifying losses and in restoring or creating wetlands, if private mitigation banking is to become an accepted part of the 404 permit process then regulatory practices and interagency agreements must provide clear procedures for the concept. To avoid or minimize litigation, guidance is needed for prospective bankers in establishing a bank and for borrowers on how to utilize banks in the permit process. While flexibility is needed to accommodate local and regional issues, there must be some regulatory mandates to direct agencies and guide the development, permitting, and monitoring of private mitigation banks.

WETLAND CREATION AND MITIGATION BANKING: AN INDUSTRY VIEWPOINT

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The Bush administration created a policy of "No Net Loss of Wetlands". The Clinton administration has embraced this policy and expanded its scope. The creation of mitigation banks was proposed as a compliance option for the "No Net Loss" policy.

On August 25, 1993, the Corps of Engineers (COE) revised their definition of dredge and fill activities. Under this new (Tulloch) rule, a 404 permit will be required for mechanized land clearing, ditching, and other excavation activities that destroy,

degrade, or have an adverse effect on any aquatic function of the waters of the US, including wetlands.

The Tulloch rule will bring increased scrutiny to all mining operations which are conducted below the elevation of the regional groundwater table. Since created wetlands need only hydrology and wetland vegetation to be considered a wetland by the COE, companies will be at risk of violating the law if their mining areas or tailings ponds with appropriate hydrology develop wetland vegetation.

The COE considers the created wetlands non-jurisdictional when they are part of the active mining operation; however, as soon as they go "inactive" they become jurisdictional with COE authority. Since jurisdictional wetlands cannot be used for mitigation, the mining industry will not only lose the use of these areas for future mitigation purposes, but will also be at risk of violating the law during the restoration and reclamation of former mining areas.

Successful mitigation banking will require cooperation from the governing agencies to exclude wetlands created by mining from jurisdictional authority until after they are reclaimed and banked. Mining companies must become more proactive by entering into Memorandum of Agreements (MOAS) with the COE, US EPA, US Fish and Wildlife Service and the states that define when created wetland areas are considered inactive and jurisdictional and to convert the reclaimed wetlands into mitigation banks.

Unimin has attempted to enter into just such a MOA. Letters of our intent concerning wetland creation and mitigation banking were mailed to each of the 14 COE districts of our 25 mining operations. To date, Unimin has only received five responses to our letters.

The mitigation banking process has several problems which will need to be addressed if it is to work:

1. A standard quantifiable method needs to be developed to evaluate wetlands, mitigation credits, and the corresponding mitigation ratios.

2. There are too many restrictions on how mitigation banks are to be created and on where the credits from the banks can be use.

3. Dealing with three different agencies and conflicting agendas during the mitigation banking process can result in unreasonable compliance solutions for the regulated community.

4. Created wetlands should be bankable regardless of when they were created.

The regulatory agencies must be more flexible in their

The regulatory agencies must be more flexible in their interpretation of the "No Net Loss Policy" and on how mitigation banks are created and used. If not, the regulated community will be left without a reasonable way to comply with the new rules and policies.

AN OVERVIEW OF WETLAND MITIGATION BANKING: THE NATIONAL WETLAND MITIGATION STUDY FINDINGS AND ONGOING STUDIES

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Alexandria, VA 22315

The findings of the first phase of the National Wetland Mitigation Banking study being conducted by the US Army Corps of Engineers Institute for Water Resources (IWR) have been presented in a series of 6 reports. Wetland mitigation banking, although practiced for more than 15 years, is a concept still in its infancy. However, banking is very much in an exponential growth phase in terms of implementation. Most of the more than 40 banks in operation by summer 1992 were less than five years in existence (see Figure 1). These banks represented a variety of institutional arrangements. For the most part, however, the banks were single-client banks (in which the user is also the client) sponsored by state agencies. Very few banks offered compensatory mitigation credits for general development use. Such general use banks have also been referred to as commercial banks (or credit ventures). In early 1992, all operating commercial banks were sponsored by public agencies. However, in the past three years numerous privately-sponsored commercial banks (also known as entrepreneurial banks) have been proposed and several implemented. Among the most critical issues that affect the financial success of banks, and thus the willingness on the part of the prospective banker to get involved in banking, is the timing of debiting versus accrual of credits in the bank.

The overall evaluation of banking presented in the National Wetland Mitigation Banking First Phase Report (IWR, 1994) was as follows: (1) when properly planned and executed, wetland mitigation banks may provide effective means to mitigate unavoidable loss of wetlands, essentially by providing practicable mitigation alternatives; (2) while there have been a significant number of banks with substantial problems or that have failed, in general existing banks have been ecologically successful or are expected to be successful; and (3) the Corps, as the principal regulatory authority, should assume a more direct role in bank establishment and the certification of credits, while providing continuous

oversight in their operation.

The second phase of the national banking study is focusing on commercial banks (and similar credit ventures) and on utilization of banks to facilitate watershed-based management, and vice-versa. Many innovative approaches to producing compensatory mitigation in the form of banks have been proposed. The national study is preparing a taxonomy of commercial banks based on a review of operation and proposed commercial efforts. Requirements for economic and ecologic success for each type of commercial bank will be described.

There is increasing recognition by regulatory and resource agencies and other experts that banking can best meet the nation's wetland goals if carried out within a context of recognized comprehensive or watershed based plans. The Clinton Administration's wetland policy statement (White House Office on

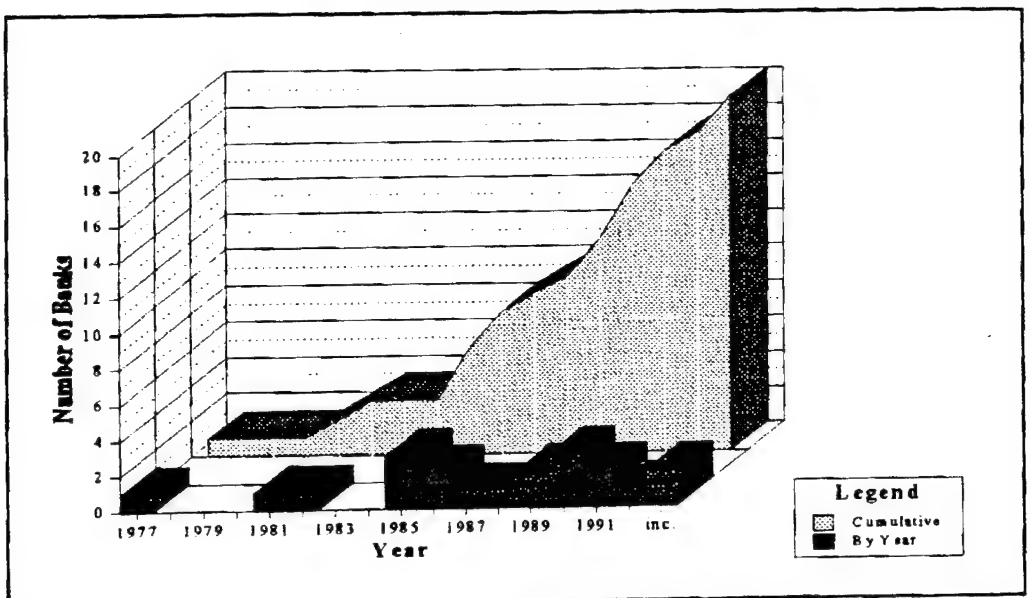

Figure 1. Date of Implementation for Case Study Banks for 20 operational banks, approximately one-half of population in 1992)

Environmental Policy, August 1993) supports wetland mitigation banking in the context of wetland planning as does the proposed Federal Guidance for the Establishment, Use and operation of Mitigation Banks (Federal Register, March 6, 1995). The national study is examining a number of watershed planning efforts that involve wetlands to identify success and barriers to success and applications to banking.

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White House Office on Environmental Policy. August 24, 1993. Protecting Americals Wetlands: A Fair, Flexible, and Effective Approach.

COMMERCIAL CREDIT VENTURES: A REVIEW OF RECENT EXPERIENCES

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Paul Scodari
King and Associates
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Private entrepreneurs have begun to restore and create wetland acres and functions in anticipation of being able to sell "credits" to permit applicants in need of mitigation. As part of the National Wetland Mitigation Banking Study being conducted by the Corps of Engineers Institute for Water Resources, these private sector efforts were examined. The different forms of wetland mitigation banking are described with particular emphasis on banks developed to make "commercial sales" to permit applicants. After presenting a taxonomy of commercial banks, this paper reviews the experience to date with private credit sales and explains the regulatory safeguards that have been used to assure that private credit sales secure successful mitigation. A list of regulatory requirements is then presented that can simultaneously secure successful mitigation and a positive economic return for private entrepreneurs. Particular attention will paid to the use and design of performance bonds.

STATEMENTS ON THE PROPOSED FEDERAL INTERAGENCY GUIDANCE ON MITIGATION BANKING

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Proposed Federal interagency guidance on mitigation banking was published in the Federal Register on March 6, 1995, to solicit public comment. This guidance represents the consensus of five agencies -- Army/Corps of Engineers, Environmental Protection Agency (EPA), Natural Resources Conservation service, Fish and Wildlife Service, and National Marine Fisheries Service -- regarding policy for the establishment, use and operation of mitigation banks. It signifies an important accomplishment among these agencies endorsing mitigation banking in support of the Administration's Wetlands Policy Plan (August 1993).

This effort was undertaken for the purpose of providing guidance to the field operating activities of the involved agencies as a means to achieve consistency regarding decisions on mitigation banking. In achieving this stated purpose the policy fully supports and encourages mitigation banking in the private sector. The agencies recognize the important contributions the private sector can make to mitigation banking, and hence toward achieving the Nation's goal of a no net loss of wetlands, and furthering the goal of a net gain over the long term.

Clearly, mitigation banking offers an alternative to project-specific mitigation under the Clean Water Act Section 404 Regulatory Program. Under the "Swampbuster" provisions of the Food Security Act, mitigation banking can contribute significantly toward restoration of prior-converted wetlands as a means to mitigate for wetland losses due to agricultural activities/conversions. It is the intent of the policy guidance to address mitigation banking as it is applied to these programs.

The proposed Federal guidance maintains the sequencing established in the Memorandum of Agreement between the Department of the Army and EPA (February 1990) -- first, avoid impacts; second, minimize impacts; and third, compensate for remaining

unavoidable impacts to wetlands and aquatic resources. Mitigation banking should be used when opportunities for on-site compensation are not practicable or when use of a mitigation bank is environmentally preferable to on-site compensation. The guidance is specific on key policy issues at the national level, flexibility has been maintained to allow field operating activities latitude in interpreting the guidance to address regional needs and interests. It is not designed to hold mitigation banks to higher standards than those for project- specific mitigation sites.

With respect to the issues of on-site versus off-site, and in-kind versus out-of-kind mitigation, the policy emphasizes the importance of practicability and environmental desirability. There exists a preference to compensate for the loss of wetland functions on-site, and a recognition that some functions such as flood control or water quality may best be replaced on-site. As with all compensatory mitigation, it is essential, on a case-bycase basis, to distinguish between wetland functions that are critical to on-site replacement, and those which may net greater environmental benefits through off-site replacement. Mitigation banks increase the opportunity for successful mitigation through off-site compensation of some functions, such as habitat, Banks may also offer opportunity for out-of-kind compensation, These decisions are directly tied to the permit evaluation process and are driven by the determination as to what is appropriate and practicable mitigation. Similarly, decisions accepting out-ofkind mitigation may result in greater environmental benefits.

The policy guidance covers a broad range of issues germane to mitigation banking; some of the more salient ones are mentioned here. In addition to any required Section 404 permits, all mitigation banks need to have a banking instrument to document interagency concurrence as to how the bank will be established and operated. All participating agencies are signatory to the banking instrument. The Mitigation Bank Review Team is comprised of the signatory agencies, and its primary role is to facilitate the establishment of mitigation banks through the development of banking instruments on a consensus basis.

The Federal guidance endorses (1) watershed planning for integrating mitigation banking goals and objectives, (2) preservation of wetlands, (3) self-sustaining design, (4) flexibility in the timing of withdrawal of credits as an incentive to private sector interests, and (5) long-term management and protection strategies. The document provides guidance on establishing (1) goals and objectives, (2) site selection, (3) bank service areas, (4) monitoring and remedial action, and (5) financial assurances.

Consistent application of this policy guidance by the agencies will serve to further the goals of no net loss and a net gain in the country's wetlands resource base. Isn't it about time?

SESSION RE15

RESTORATION, PROTECTION, AND CREATION: CHESAPEAKE BAY WETLAND RESTORATION

Ms. Trudy Olin, Chair

HART-MILLER AND POPLAR ISLANDS: RESTORATION OF LOST FISH AND WILDLIFE HABITATS IN CHESAPEAKE BAY, MARYLAND

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Baltimore, MD 20203

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Hart-Miller Island (HMI), an 1100-acre confined placement island for dredged material in Chesapeake Bay, Maryland, was constructed in the early 1980's. The island's destiny is to become a wildlife and wetland habitat, which is used for education and research as well as passive recreation such as bird watching. The island is nearing completion, with little remaining capacity, and a draft design is in review for HMI's South Cell that includes combinations of shallow aquatic, wetland, upland, and island habitats. As soon as the North Cell is completed, a design for it will also be completed. The current operations and testing facility will be converted to a research, education, and museum visitors center. Other user- friendly features will be added over time: hiking trails, a boardwalk into the wetlands, covered benches, observation towers and hills, and an additional boat dock near the visitors center.

The HMI project has been carefully coordinated since 1974 with three groups: (a) Citizens Committee, (b) Governor's Advisory Committee, and (c) Technical Advisory Committee. The project was a joint effort of three agencies in the State of Maryland and the US Army Corps of Engineers; its primary funding was by the Maryland Port Administration (MPA), its sponsor.

The HMI holds 62 million cubic yards of dredged material. The MPA and Corps has no new placement sites on-line, but a major new approved site is being rapidly planned and designed. This is Poplar Island (PI), off Maryland's Eastern Shore. The site has very strong support and coordination of the State, the Corps, and the US Fish and Wildlife Service, and has been approved by the NOAA National Marine Fisheries Service and the US Environmental Protection Agency.

PI is a natural island of several hundred acres that has eroded to less than 6 acres in the past 150 years; it was an intensely used wildlife site, and was fringed by important fish nursery salt marshes. The Technical Advisory Committee for PI is working out details on an island design of approximately 1500 acres with MPA's engineering contractors that will build back an island on roughly the same footprint of the old island using reinforced and armored dikes to prevent erosion. It is being positioned to avoid active and dead oyster and other shellfish areas, and will be connected to four remnants of existing islands (mostly submerged at high tide).

Concepts call for (a) baseline engineering and environmental data collection; (b) combinations of intertidal marshes and perched wetlands, transition zones, and uplands; (c) innovative engineering on the dikes, crossdikes, and cells that will allow maximum placement of dredged material within the island to form the habitats. Two primary goals have emerged from the Committee's work: (a) maximize fish and wildlife biodiversity in the overall design, and (b) achieve maximum placement and dewatering/ management of the dredged material that will provide the MPA and Corps with a long-term placement site and gain a favorable benefit/cost ratio for the project. Objectives based on general project goals are being developed.

PI will begin construction in 1995, and will follow the general approach developed for HMI. Its ultimate destiny will provide a badly needed increase in Chesapeake Bay fish nursery areas and waterbird/waterfowl nesting and migratory use.

EASTERN NECK NATIONAL WILDLIFE REFUGE SALT MARSH: INNOVATIVE STRUCTURES AND BIOENGINEERING

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The shorelines at Eastern Neck National Wildlife Refuge, on Chesapeake Bay's Eastern Shore, have been steadily eroding for many years. In an attempt to hold the line, the US Fish and Wildlife Service invested in armoring along the shore. Part of this riprap was used innovatively in combination with dredged material from the Chester River to (a) prevent future erosion, and (b) restore salt marsh and fish nursery areas.

In 1993, a line of 100-ft-long, with 100-ft-spacings, detached riprap structures were installed from a shore point at Eastern Neck out into 4-ft-deep Bay water to provide a stillwater area approximately 300-ft-wide. At the end of the detached riprap breakwaters, two geotextile tubes were filled with sand dredged material to continue the breakwater line and so that most of the dredged material being placed behind the structures would be protected. Sandy dredged material was pumped between the structures and the eroding shoreline to an intertidal elevation. The area was planted with _Spartina alterniflora_ and _Spartina patens_ in summer 1993, and finished planting in summer 1994.

Several engineering and environmental tests were conducted at Eastern Neck: (a) use of detached riprap structures to protect shorelines in Chesapeake Bay; (b) use of detached sediment-filled geotextile tubes to protect shorelines in Chesapeake Bay; (c) ability of erosion control matting grown with _S. alterniflora_ to withstand a more than 30-mile windfetch; (d) survival and growth of individual transplants of both species at the site; (e) the movement, consolidation, and stability of the dredged material under conditions of partial protection; and (f) fish and wildlife use of the new wetland area. This was an interagency project, with funding by the US Fish and Wildlife Service and the US Army Corps of Engineers (Baltimore District and Waterways Experiment Station's Wetlands Research Program), and cooperation by two state agencies, private citizens' groups, and other federal agencies. Much of the planting work was accomplished with volunteers.

Results and success of tests were mixed, and monitoring is continuing. In 1993-1994, Chesapeake Bay endured one of the coldest winters on record, and the site had 14-ft-high ice floes rafted on it. Meanwhile, wave energy moving through the openings in the detached breakwaters sorted and moved much of the dredged material and washed out the low tidal zone individual plantings. The substrate is visible only a low tide in many parts of the site. The high marsh (_S. patens_) survived waves and winter storms, and is thriving. The ice did no damage to either the hard structures or the geotextile tubes. Erosion control matting tried in late 1993 without well-established plant material did not survive, and was

re-tested in 1994. As winter 1994-1995 began, the mat test areas and high marsh were surviving well. Fish seines have pulled in large numbers of small fish using the salt marsh and shallow water areas behind the breakwaters. Numerous waterbirds and other species have been observed on the site, including bald eagles, white-tailed deer, and small mammals.

At this writing, efforts are being made to close most of the open areas between the riprap structures to afford more protection to the new wetland. The information from Eastern Neck was also being used to design placement of geotextile tubes at Barren Island, a similar Chesapeake Bay project being constructed in December 1994. The 100-ft spacings used at Eastern Neck are being reduced to 10-ft spacings at Barren Island, and several configurations of tube placement are being tested.

This highly-visible project has been closely watched and visited by coastal engineers, biologists, agency headquarters, and Congress. There are many lessons to learn from the tests conducted at Eastern Neck that will be applied in future wetland restoration and shoreline protection projects in Chesapeake Bay.

KENILWORTH MARSH: A CLASSIC WETLAND RESTORATION SUCCESS STORY IN THE NATION'S CAPITOL

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Kenilworth Marsh, a 35-acre area located in the National Aquatic Gardens in Washington, DC, was restored in 1992-1993. A combination of engineering and environmental techniques, including (a) temporarily placed, large water-filled geotextile tubes that were removed after dredged material had sorted and consolidated and marsh establishment had occurred, (b) anchored hay bale structures that separated low marsh from high marsh planting areas, (c) compartmentalization of planting units within two large cells, (d) bringing the substrate to an intertidal elevation with dredged material sediments, and (e) planting of potted seedlings (both herbaceous and woody fresh marsh species) were used to restore the wetland.

Species planted in the wetland included: _Nuphar advena_,

Sagittaria latifolia, Sparganium americanum, Sparganium eurycarpum, Scirpus americanus, Scirpus validus, Carex stricta, Iris versicolor, Peltrandra virginica, Polygonum spp., Pontederia cordata, Sauruus cernuus, Leersia oryzoides, Hibiscus mosheutos, and Cephalanthus occidentalis. By the end of the second growing season, stands of Typha latifolia and Zizania aquatica had colonized both cells and were spreading. The marsh at two years of age is still quite diverse, but is beginning to be dominated by the more aggressive species. When it was planned and designed, an objective was to let ecological succession take the marsh to a climax stage without further management, which would finally result in wooded riverine habitat interspersed with fresh marsh and shallow open water.

Design features also include canoe channels, recreational trails, and overlooks. Work was funded by the US Army Corps of Engineers, and its partners were the National Park Service, the DC Council of Governments, and the US Fish and and Wildlife Service. Long-term environmental and engineering monitoring by an interagency group is part of the overall plan of action. Data collected through the fall of 1994 show the marsh densely growing with planted and colonizing species and project goals, which were largely based on functions to be achieved, being successfully met. The dredged material colonized so rapidly with a broad variety of wetland plants that planting of the site was unnecessary; however, planting was done to (a) help compete against any possible invasion of common reed, and (b) to ensure rapid wetland development.

Using lessons learned at the restored wetland, a similar wetland will be built using dredged material at Kingman Marsh across the Anacostia River from Kenilworth Marsh. Kenilworth Marsh has been observed and visited by various agencies' headquarters officials, Congressmen, and District of Columbia elected officials. It received the Army's Environmental Design Award for 1994.

SHORELINE STABILIZATION AND WETLAND RESTORATION AT BARREN ISLAND AND HISTORIC SMITH ISLAND, CHESAPEAKE BAY, MARYLAND: INNOVATIVE GEOTEXTILE TUBE TECHNOLOGY

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Chesapeake Bay is undergoing extensive erosion along its shorelines, but especially, its islands are eroding and disappearing at an alarming rate. The US Army Corps of Engineers has undertaken protection and restoration of two such islands, one manmade and the other natural, in the Bay using innovative technology with a combination of geotextile tubes and aprons, use of sand dredged material, and restoring intertidal elevations for wetland restoration.

Barren Island is located near the Honga River, in Chesapeake Bay, Maryland. A section of Barren Island was constructed of dredged material by the US Army Corps of Engineers several decades ago; it was added to during a dredging cycle in the early 1980's for black duck and least tern nesting habitat. That application of dredged material was designed to include planted salt marsh areas surrounding the island (Spartina alterniflora and Spartina patens), and a bare crown capped with shell cultch to provide optimum substrate for nesting terns. The least tern design was highly successful, with colonies still occurring on Barren Island. Black ducks and other waterbird/waterfowl species also use the planted salt marsh.

Neither prior habitat construction project provided shoreline protection for the island. As a consequence, it has continued to erode. Using lessons learned from four other geotextile tube projects by the Corps conducted at Eastern Neck National Wildlife Refuge and Smith Island in Chesapeake Bay, and at West Bay and Aransas National Wildlife Refuge in the Texas Intercoastal Waterway, a project using tubes at Barren Island to stop erosion was designed. The US Fish and Wildlife Service (FWS) is contributing funding for the tubes, and the Corps is providing the dredged material for filling them, funding and supervising the work, and conducting follow-up monitoring.

Construction of the project began in December 1994 and is still underway. Along the approximately 1.5-mile stretch of tubes, the Corps and FWS are testing two tube configurations: (a) single-line 100-ft-long tubes placed 10-ft apart at ends, and (b) staggered double-line 100-ft-long tubes placed with approximately a 10-ft overlap, with spacings for intertidal connection between the two lines. Other promising configurations may be tested while the project is under construction. Any remaining sand dredged material may be placed between the tubes and the shoreline to hasten wetland recovery.

Smith Island, a natural island in Chesapeake Bay, was settled in the early 1700's by Englishmen; many of the residents speak with an Old English dialect and there are only a few surnames existing there. Smith Island is also eroding badly, and erosion has reached the point of jeopardizing the airport, homes, and other historic features of the island.

The US Army Corps of Engineers has installed a permanent frontline protective structure made from geotextile tubing. The double-lined woven-fabric tube is being filled with sand dredged material. It is the largest sediment-filled tube tested in the United States to date, and is 2000-ft long, 20-ft wide, and 7-ft high. The geotextile fabric used to construct the tube has a 20-30 year life under ultra-violet conditions. Dredged material is being placed between the tube and the eroding shoreline to recover some of the island's lost salt marsh.

The tube was filled in November-December 1994. Problems were encountered when the contractor used too small a dredge; he used a 10-inch dredge, which would not maintain enough of a head to shape the tube into the correct configuration. Work had to be stopped until a larger dredge could be mobilized and used to complete filling the tube. The tube and site will be monitored for stability, settling, and other engineering considerations. It is very important to document all aspects of this large-size tube, because large tubes are being considered for other Corps and state projects, both in Chesapeake Bay and other estuaries.

Several other wetlands in Chesapeake Bay have been protected and restored using similar technology, and lessons learned from these are being applied to wetland restoration projects in Galveston Bay in Texas, Delaware Bay in New Jersey and Delaware, the Hudson River in New York, and other sites in Chesapeake Bay.

SURVIVAL AND GROWTH OF NURSERY-STOCK WOODY PLANTS IN CONSTRUCTED FORESTED WETLANDS IN CENTRAL MARYLAND

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The survival and growth of 1841 nursery-stock woody plants that were planted in 3 constructed forested wetlands in fall 1992 were evaluated during 1993 and 1994. The wetlands were constructed as mitigation areas to offset losses of natural wetlands due to highway construction. All trees and shrubs were 2-year old, balled-root stock and were tagged during the spring of 1993. Tagged transplants were measured (height, diameter, canopy) in the fall 1993, spring 1994, and fall 1994. Signs of animal damage by deer, rodents, or insects were recorded. Percent moisture of the soil at the base of each transplant was determined in the fall 1994 with a hand-held battery-operated
moisture probe.

After 2 years, 582 of the 1240 tagged tree transplants from the 3 mitigation sites had died (Table 1). Green ash (Fraxinus pennsylvanica) had the lowest mortality (14%) and pond pine (Pinus serotina) had the highest mortality (86%). Cumulative mortality of the other tree species ranged from 35-56%. The time of mortality for all 11 species was evenly distributed over the 2-year period with average cumulative mortality of 22% after 1 year, 36% after 1.5 years, and 48% after 2 years.

Of the 601 tagged shrubs, 367 were dead after 2 years (Table 2). Spicebush (Lindera benzoin) and bayberry (Myrica pennsylvanica) had the highest mortality, 97% and 96%, respectively. Buttonbush (Cephalanthus occidentalis) had the lowest mortality (10%) and mortality of other shrub species ranged from 22-86% The time of mortality for all 10 shrub species, like the trees, was evenly distributed over the 2-year period with 22% after 1 year, 40% after 1.5 years, and 58% after 2 years.

Chi-square analyses indicated significant differences (2=120.4, P<0.001) in mortality among species of transplants at a site. There also were differences in overall mortality and mortality of certain species among the 3 sites. During the 2- year period most of the mortality was attributed to excessive water conditions during the growing season. Moisture readings of the soil at each tree revealed that there was a higher percent moisture reading for the dead trees (x = 87%) than for the live trees (x = 84%) (F=12.68, N=905, P=0.0004). More readings will be taken in the future to see if differences in percent moisture can be detected for individual tree species in regards to survival and growth.

Wildlife damage may also have been a major factor in the mortality of the woody plants. At one site, a population of meadow voles (Microtus pennsylvanicus) girdled 37% of the trees. Voles girdled all species except pond pines, the only conifer. The high vole population appeared to be related to the dense grass cover that provided excellent cover and food. Other wildlife damage included browsing and antler rubbing by white- tailed deer (Odocoileus virginianus).

Growth measurements of the woody plants at the 3 sites indicated that most of the live transplants decreased in height due to dieback of the mainstem. At 2 of the sites, all species showed decreased height on average and at the other site, 14 of the 18 species showed a general decrease in height. The species that increased in height on average were green ash, pond pine, black willow (Salix nigra), and ninebark (Physocarpus opulifolius). Results of canopy and diameter measurements were similar to height data and indicated that woody plants in these constructed forested wetland sites were under stress.

SESSION RE16

RESTORATION, PROTECTION, AND CREATION: GENERAL RESTORATION AND CREATION THEORY

Dr. Lawson M. Smith, Chair

DEVELOPMENT OF MONITORING PROGRAMS FOR THE PURPOSE OF EVALUATING NATURAL AND MODIFIED WETLAND SYSTEMS

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Introduction

Monitoring has always been an extremely important aspect of environmental evaluation. However, often the reasoning for monitoring, the field and analytical methods used, and the ultimate use of information gathered is unclear or unsuited to the situation at hand. A basic issue in the development of monitoring programs is whether the system under study is a natural environment or an experimental system such as a created or restored wetland. The distinction between natural conditions versus experimental ones is significant in terms of the expectation of the types of change, if any, that may occur. Natural systems may change over time as a result of natural environmental cycles such as seasonal precipitation and temperature effects, or tidal flux. Experimental systems are ones such as created wetlands. The other case would be natural wetland environments that are being modified over time due to a human- caused influence such as chemical spills or physical modifications to the habitat or hydrology such as diking.

Monitoring has been and will continue to increase in its significance especially for evaluating a range of wetlands situations including determining restoration success (Baye 1994, DeWeese 1994) and evaluating man-caused impacts to habitat (McCarten 1994). Due to the increased significance of the findings from monitoring studies, there will be a concomitant increase in scrutiny of field and analytical methods in a study by agency and professional scientists. In order to develop sound and justifiable monitoring programs some important questions can be asked that will help elucidate the approaches to design and implementation of monitoring studies.

Purpose and Process of Monitoring Design and Implementation

The following is an annotated outline that begins to address how to approach a potential monitoring study:

1. Goals and Objectives- Asking and identifying what the goal(s) of a monitoring study is fundamental to the initiating the study. Establishing specific objectives will provide guidance in the selection of field and analytical methods to be used since the objectives should specify what data is to be collected.

2. Underlying Assumptions- The assumptions are most closely associated with asking the question on whether we expect a change in conditions such as vegetation cover or species composition, and to what degree that change is expected to occur.

3. Logistics of Monitoring- Under ideal conditions everything can be monitored simultaneously, and there is unlimited time and budget. The main question to be asked is can the amount of data needed to fulfill the objectives be collected in time and under the funding limitations?

4. Type and Quantity of Data- The type and quantity of data are critical in determining whether specific objectives are met. In the case of wetland restoration, success criteria often involve meeting goals of 85 percent of something such as vegetation cover or number of plants.

5. Methods of Data Analyses- What level of data analyses will be needed to fully evaluated if specific objectives and the overall goal(s) have been met? Often direct analysis such as quantitative values are sufficient.

6. Results and Models- The results of monitoring hopefully will provide answers as to whether or not the goals of the study were met. A final question would be does the analyzed data represent what we perceive to be an accurate model of the system. In other words, does our logic and understanding of the system we have been monitoring relate well with what our data explains.

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HYDROGEOLOGICAL INFORMATION, WETLAND SITE SELECTION, AND WETLAND DESIGN

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Hydrogeological information is essential in successful wetland restoration or creation site selection and design. Information interpreted from US Geological Survey 7.5-minute Quadrangles, US Department of Agriculture Soil Surveys, US Fish and Wildlife Service National Wetland Inventory maps, geologic maps, planning maps, and site-specific local sources generally provide sufficient data for a hydrogeological assessment in initial site selection.

Data from three Illinois mitigation sites demonstrate the utility of using hydrogeological information during the design of wetland projects. At a site on the Mississippi River floodplain near East Hannibal, Illinois, the precise hydrogeology of a floodplain site with complex sub-surface stratigraphy must be considered to enable appropriate design of the site for wetland mitigation. Two urban sites in the Chicago area involve wetland creation along small streams. In one case, limited water sources suggest abandoning the site. In the other case, water is not the limiting factor but groundwater and surface water elevations must be carefully evaluated in the design process to attain the maximum acreage of wetland from the site.

Goal setting for wetland restoration and creation and the correct sequencing of data gathering, data assessment, and wetland design are keys to a successful wetland restoration or creation project.

DESIGN CRITERIA FOR WETLAND RESTORATION AND ESTABLISHMENT

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In order to enhance the chances of success in wetland restoration and establishment projects, it is important for the

wetland team to consider the appropriate design criteria to achieve specific wetland function in the type of wetland being engineered. As part of the US Army Corps of Engineers Wetlands Research Program (WRP), guidelines for wetland design were developed for the major hydrogeomorphic types of wetlands and the principal wetland functions. Wetland design criteria are defined as instruction or guidelines for developing biological, hydrological, geotechnical (soils and geology), and engineering design specifications for restoration and creation of a wetland of a specific type to achieve specific functions. Design criteria should not be confused with design specifications, which are detailed designs of features such as hydraulic structures. The design criteria were developed from the analysis of previous wetland projects, WRP research sites, and state-of-the-art concepts in wetland science and engineering.

WETLAND RESTORATION AND CREATION HANDBOOK

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The Water Resources Research Institute (WRRI) has completed a handbook defining techniques for restoration and creation of wetlands. This handbook was developed for the North Carolina Division of Coastal Management to provide guidance to restore and create wetlands in the southeastern United States. The main focus of this handbook is on vegetative aspects of restoration and creation. A preliminary overview of this project discussing only the first section dealing with the literature review was first presented at the Army Corps of Engineers-Waterways Experiment Station (ACOE-WES) workshop. This workshop was held August 1993 at St. Louis, Missouri and titled "Engineering For Wetlands Restoration: A National Workshop." A survey was also conducted during the workshop and the results are included in one section of the handbook.

The document has three sections including a literature review, a questionnaire survey, and a section on wetland restoration and creation techniques. The literature review section covers more than 1600 references and provides some statistics about type of source, year published, and specific publications on the subject. Most of the literature was found to be scattered and rarely complete. Wetland experts were needed to help fill in information gaps. The questionnaire survey section summarized information that was gathered from a questionnaire that was sent to 400 wetland restoration and creation "Practitioners." There were 29 questions in the areas of organization/classification, record

keeping, sources of information, material needed in handbook, personal, and plant/soil/hydrology information. Results of the survey include (1) over fifty percent of the participants work for federal agencies; (2) most work occurs in one state and one region of the United States; (3) main wetland type specialized in was freshwater wetland; (4) key informational sources were two federal agencies; and (5) most important topic to include in a handbook was hydrology restoration (Figure 1). The wetland restoration and creation techniques section covered six wetland types including saltwater/brackish marsh, freshwater marsh, bottomland hardwood forest, swamp forest, pocosin, and salt shrub. Each combined wetland type has a profile, overview, preparation of soil and site, hydrology, planting, time frame, cost, reference sites, and contacts (Figure 2). The most complete information was found for the saltwater marsh wetland type because of the earlier focus on this type in the 1970s. There was little information on restoration or creation of pocosin/salt shrub wetland type due to their limited geographic distribution and lack of research attention. Other related information is included in the appendix section. These topics include national and regional climate centers, outline of Soil Conservation Service (now the Natural Resources Conservation Service) and Army Corps of Engineers restoration and creation guidelines, wetland restoration/creation survey form, wetland classification comparison, wetland vegetation sources for the Southeast, and characteristics of wetland species.

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Figure 1. Information for Handbook

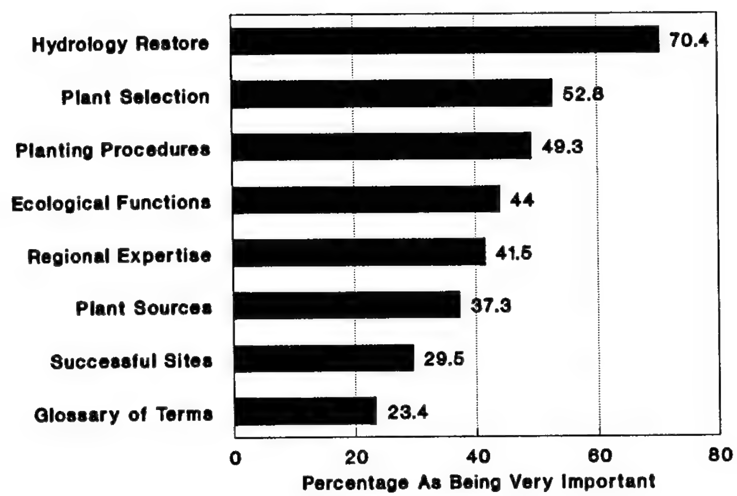
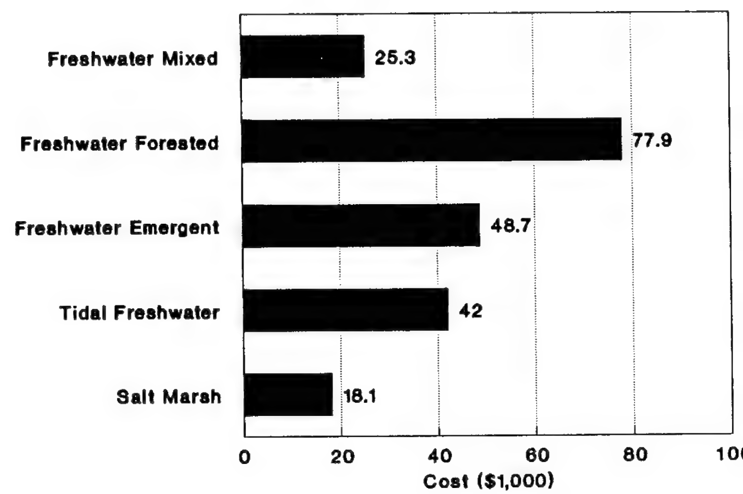


Figure 2. Average Cost Per Acre



Source: King and Bohlen, 1994

PERFORMANCE STANDARDS FOR COASTAL WETLAND RESTORATION

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With continued development and degradation of coastal wetlands, there are more and more opportunities, and pressures, to restore them. Along with the increased opportunities, there has been increased concern about the success of wetland restoration. Several studies have indicated that a substantial fraction of wetland restoration projects may not be successful (Eliot 1985, Race 1985, BCDC 1988, Zentner 1988). One of the problems these studies have identified is that relatively few restoration projects have clearly defined goals, making it difficult to judge success. Performance standards, and follow-up monitoring to determine whether they have been met, are necessary to ensure that a restoration accomplishes what it is supposed to accomplish. In this paper, I use two case studies from Southern California to examine some of the desirable features of wetland performance standards and some of the problems and issues associated with monitoring them.

Most scientists agree that the goal of habitat restoration is to restore the functions of natural habitats, so it follows that the performance standards should reflect this goal (Zedler et al. 1988). In the past, many different approaches have been used for setting standards for wetland restoration, but these have rarely focused on habitat or ecosystem functions. Because the goal of restoration is to restore functions, a list of ecosystem functions should serve as the framework for performance standards; such as list should include species-level functions, such as the support of plants or fish, community-level functions, such as support of species and genetic diversity, and ecosystem- level functions, such as nutrient cycling and productivity.

In this paper, I illustrate the use of functional performance standards using two recent coastal wetland restoration projects in Southern California: the Connector Marsh in San Diego, which was restored by Caltrans as mitigation for damage to a natural marsh, and the San Onofre Nuclear Generating Station (SONGS) wetland restoration, which is a mitigation requirement for impacts on marine fish. The specific standards for both projects will be discussed in the presentation; both projects have required some of the most progressive performance standards to date.

How do these standards compare to a comprehensive framework of ecosystem functions? As shown in Table 1, neither covers even a majority of the functions. One reason for this is that both sets of standards are ad hoc. They are based on an understanding of the

factors that should be important for the success of a restoration, but not following an explicit, systematic procedure to make sure all the important factors are included.

The quantitative performance standards and long-term monitoring required for the Connector Marsh and SONGS projects will help ensure that the restored wetlands are successful. In addition, they can show us where remediation is needed, and they are necessary for building the knowledge based we need to improve the chances of success. If we want to be sure that a restored wetland functions like a natural one, we need to have performance standards that encompass the full range of natural functions. However, even the standards for the Caltrans and SONGS projects exclude many levels of ecosystem function. To provide more comprehensive performance standards, we need to understand wetland functions better and we need to continue to develop performance standards, including developing methods for measuring many of the critical ecosystem functions.

Table 1. Coverage of ecosystem functions by performance standards for the Caltrans Connector Marsh and San Onofre Nuclear Generating Station (SONGS) mitigation wetland. Open circles and text indicate the performance standard covers only some aspects of a particular function.

Function	Caltrans	SONGS
SPECIES LEVEL FUNCTIONS		
Support of:		
fish	(as forage)	o
plants	o	o
insects	(as forage)	
aquatic invertebrates	(as forage)	o
birds	clapper rail, least tern	o
other vertebrates		
COMMUNITY LEVEL FUNCTIONS		
Support of species diversity		o
Support of genetic diversity		
Resilience		
ECOSYSTEM LEVEL FUNCTIONS		
Nutrient cycling	N-fixation	
Productivity/Production export		(as forage)
Ecological integrity		
Linkage to other ecosystems		

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SESSION SM8

STEWARDSHIP AND MANAGEMENT:
OTHER MANAGEMENT TECHNOLOGIES II
Ms. Mary F. Flores, Chair

EFFECTS OF FOREST MANAGEMENT ON WETLAND FUNCTIONS: RESULTS FROM THE FIRST FIVE YEARS OF THE FOREST INDUSTRY'S WETLAND RESEARCH PROGRAM

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Introduction

Forest wetlands are valued by society for the many ecological functions they perform. They are also important sources of wood for the forest products industry. Timber management, particularly harvesting and pine plantation establishment, has been cited as a threat to wetlands (US Environmental Protection Agency 1994, Department of the Interior 1994). However, silviculture has also been identified as a compatible use of wetlands that can provide income to landowners without causing significant loss of wetland functions (The Conservation Foundation 1988). Data to support either of these divergent views are lacking.

In light of this deficiency, the forest products industry initiated a cooperative research program on management of forest wetlands in 1989 (Shepard 1993). The program is organized through NCASI, the industry's environmental research organization. The program's overall objective is to help forest landowners manage wetlands for timber production while protecting important wetland functions such as those associated with hydrology, water quality, and habitat. Funding for the NCASI program, as well as additional support from individual companies, has been approximately one million dollars annually since 1989.

The program achieves its objective by establishing cooperative research projects involving scientists from universities, state and federal agencies, and other research organizations. The program is currently supporting studies in 11 states. Funding from these partnership research projects has supported 30 M.S. and 6 Ph.D students and has resulted in over 50 publications.

Results

Hydrology. Forest management affects hydrology primarily through manipulation of vegetation. For example, following clear-cut harvesting, evapotranspiration is usually reduced and water tables generally rise. The effect is most noticeable during the first year after harvesting and diminishes thereafter as regrowing vegetation restores evapotranspiration rates. Several studies show that water tables returned to pre-harvest levels within 2 - 7 years.

Water quality. Studies of silvicultural operations such as timber harvesting, site preparation, bedding, and drainage have reported changes in water quality compared with undisturbed controls (Shepard 1994). Effects are typically small and water quality criteria are rarely exceeded. Water quality parameters usually return to undisturbed levels within a period ranging from months to a few years. The duration of these effects should be viewed in comparison with their frequency. Timber harvesting in wetland forests occurs at frequencies ranging from 20 to 50 years or more, depending on forest type and management objectives.

Habitat. Forest management affects habitat primarily by altering the species composition and the structure of the vegetation. Effects of silviculture on habitat are diverse and vary among different forest wetland types, different silvicultural systems, and length of time since disturbance. For example, studies have found both increased and decreased plant species diversity following clear-cut harvesting. Changes in habitat associated with silvicultural practices usually favor some species to the detriment of others. For example, in a bottomland wetland in Texas, abundance of one herpetofaunal species decreased following clearcutting whereas abundance of four species increased.

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BOTTOMLAND HARDWOOD ECOSYSTEM MANAGEMENT PROJECT

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Federal agency approaches to land management are undergoing a shift from parcel-specific concerns toward a more holistic, ecosystem management approach. Southern bottomland hardwood ecosystems provide important environmental services and commodity goods (Wharton et al. 1982), yet much of our knowledge of these systems comes from anecdotal information. The Bottomland Hardwood Ecosystem Management Project of the U.S. Forest Service is part of a larger, interagency initiative to provide information that will form the scientific basis for ecosystem management of these systems (Harms and Stanturf 1994).

The Project will quantify ecological processes and wetland functions by intensive study of representative systems. Forest Service scientists from Stoneville, MS and Charleston, SC are responsible for coordinating work on two primary sites: Iatt Creek in Louisiana and the Coosawhatchie River in South Carolina. These primary sites are being measured and instrumented to provide information on the functions summarized in Table 1.

Secondary sites, at which only some of the functions will be studied, have been identified on the Altamaha River in Georgia and Buckatunna Creek in Mississippi. Primary sites will be characterized over a two- to three-year period.

Concurrently with the characterization effort, Project scientists and cooperators are taking an adaptive management approach to developing consensus Expert Judgment models of important relationships (Bliss et al. In Press). Social science techniques of networking and Delphi are being used to develop these models, which will guide design of appropriate treatments for the second phase of the Project.

The second phase of the Bottomland Hardwood Ecosystem Management Project includes manipulation of the systems. In this phase, processes and functions judged critical by the Expert Judgment models will be monitored as the systems are manipulated. This will allow us to gauge ecosystem resilience and resistance.

Table 1. Functions to be measured on primary sites

Stand	Ecosystem	Landscape
	Physical Functions	
Climate	Hydroperiod	Flow paths*
Sedimentation		Hydrologic Linkages
		Mass Balance**
	Biological Functions	
Productivity	Biodiversity	Genetic Diversity
Decomposition	NTMBs	Landscape Context
Composition	Mammals	Landscape History
Structure		
Woody Debris		
Snag Production		
Herpetofauna		
Microbial Ecology		
Arthropods		
	Chemical Functions	
Nutrient Cycling	Biogeochemical Transfers	Water Quality
Sediment		
Soil		
Sheetflow*		
Carbon Cycling*		

* Iatt Creek only.

** Coosawhatchie only.

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PLANTS FOR COASTAL WETLANDS OF THE NORTH CENTRAL GULF OF MEXICO

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Specialized plants are essential to coastal wetland restoration, protection, and creation. The USDA Soil Conservation Service (SCS) at the Golden Meadow, Louisiana, Plant Materials Center (PMC) is evaluating several native wetland plant species. The objective is to evaluate and release improved wetland cultivars for conservation use in the coastal wetlands of the North Central Gulf of Mexico.

Some of the species being evaluated include: *Spartina alterniflora* Loisel., *Spartina patens* (Ait.) Muhl., *Spartina spartinae* (Trin.) Hitchc., *Paspalum vaginatum* Sw., and *Avicennia germinans* (L.) L.

Plant performance and adaptation trials are being conducted to determine suitable species for shoreline stabilization, spoilbank and levee stabilization, and barrier island and beach stabilization and enhancement.

Cultural studies are essential to the successful use of conservation plants. Studies are conducted to determine

propagation methods sexually and asexually.

COLLECTING AND COMMERCIALIZING NATIVE WETLAND SPECIES FOR SEED PRODUCTION

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Introduction

Transplanting native species is a viable and proven method of re-establishing specific plant communities. However, problems associated with handling living or actively growing plants and the perception of time-consuming technical work often relegates transplanting to a last resort option. Developing wetland rehabilitation techniques similar to standard upland practices will elevate the rehabilitation and restoration of disturbed wetlands to an accepted standard practice. Direct seeding will be the answer.

Availability of Seed

Establishing wetland vegetation with seed is, at times, not practical due to geotechnical problems such as water depth. The most common reason cited for not using seed is lack of supply.

For small sites, nursery production and hand collection can usually accommodate need. Large areas pose more challenging problems. Hand collection of seed is often impractical and transplanting can be prohibitively expensive.

During the late 1970's and throughout the 1980's, the Alaska Plant Materials Center (Alaska Department of Natural Resources) initiated a program to search for native species with commercial potential. During this period, 17 cultivars of native species were released for commercial production through the combined efforts of the University of Alaska and Alaska PMC. Twelve of these are classified wetland or riparian species (Table 1).

Answering Needs Directly

The long process of releasing plant materials has merit in the fact that materials are tested on a variety of sites and conditions. Time needed for a release is the drawback. Many important species are dropped in this process as they do not perform well in accepted (agricultural) testing programs. Therefore, in 1992, the Alaska PMC initiated a pragmatic approach to collecting and commercializing native species (Table 2). This

Table 1. Alaska-Developed Wetland Cultivars in or Near Commercial Production in 1995.

Genus/Species[1]	Common Name[2]	Cultivar	Availability[3]	Wetland Status or Other Comments[4]	Releasing Agency
Beckmannia syzigachne	American Sloughgrass	Egan	Good	Obligate	AK PMC
Deschampsia Beringensis	Bering Hairgrass	Norcoast	Excellent	Facultative FACW+	U of A
Deschampsia caespitosa	Tufted Hairgrass	Nortran	Fair	Facultative FACW+	U of A
Arctagrostis latifolia	Polargrass	Alyeska	Fair	Facultative Wetland	U of A
		Kenai	Fair	Facultative Wetland	U of A
Calamagrostis canadensis	Bluejoint	Sourdough	Poor	Facultative Obligate	U of A
Poa alpina	Alpine Bluegrass	Gruening	Good	Facultative	AK PMC
Salix alaxensis	Feltleaf Willow	Rhode	Poor	Facultative	AK PMC
Salix barclayi	Barclay Willow	Long	Poor	Facultative FACW	AK PMC
Salix bebbiana	Bebb Willow	Wilson	Poor	Facultative FACW+	AK PMC
Salix brachycarpa	Barren Ground Willow	Oliver	Poor	Facultative FACW+	AK PMC
Salix lasiandra	Pacific Willow	Roland	Poor	FACW+ Facultative	AK PMC

1 Hulten 1968
2 USDA 1994
3 Wright & Moore 1994
4 Reed 1986

Table 2. 1994-1995 Wetland Species Seed Collections

Genus/Species[1]	Common Name[2]	Amount	Germination[5]	Estimated Availability	Status[4]
Phleum commutatum	Mountain Timothy	160 g	85%	1996	Facultative, FACW
Agrostis exarata	Bentgrass	250 g	91%	1996	FACW
Trisetum spicatum	Trisetum	25 g	92%	1996-1997	Upland, FACW
Poa eminens	Spear Bluegrass	60 g	30%	1997+	FAC
Poa macrocaylx	Bigleaf Bluegrass	700 g	50%	1996	FAC
Hordeum brachyantherum	Hordeum	35 g	89%	1997	FACW
Carex machrochaeta	Sedge	560 g	69%	1996	FACW
Carex lyngbyaei	Lyngby Sedge	75 Kg	60%	1997	FACW, OBL
Juncus arcticus	Arctic Rush	320 g	86%	1996-1997	FACW, OBL
Luzula multiflora	Wood Rush	37 g	62%	1996-1997	FACU, FAC
Rumex fenestratus	Sorrel	120 g	97%	1996-1997	FAC, FACW+
Lupinus nootkatensis	Lupine	30 Kg	65%	1997	FAC
Ligusticum scoticum	Beach Lovage	380 g	64%	1997	FAC
Artemisia stellariana	Dusty Miller	72 g	96%	1996	Upland, FACU
Triglochin maritimum	Arrowgrass	35 g	94%	1997	OBL
Plantago maritima	Goose Tongue	60 g	89%	1997	Upland, FACW+

1 Hulten 1986
2 USDA 1994
4 Reed 1988
5 Wright & Vanzant *Unpublished*

relied on three basic principles:

1. Use Regionally Native Species. Identify and collect seed from species important to regions and common on disturbances. The forces of succession and natural selection prevail.

2. Direct Harvest of Seed. Using light weight, low impacting machinery, direct harvest of seed from native stands are used in seed production and reseeding.

3. Immediate Production. Eliminate the long testing period needed for formal releases by starting production without a traditional testing program.

Conclusions

With the current commitment by the Alaska PMC and a few commercial seed producers, seed should be available in Alaska within the next three years. Long-range commitments need to be established by users now.

Agencies must understand the financial and time commitment needed to bring the new material into production. Therefore, a uniform policy and commitment to use native species is the most important component if a viable native seed industry is to develop. Supply responds to demand. Commitment will make it possible.

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PRIVATE PROPERTY, TAKINGS, AND WETLANDS MANAGEMENT

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Nearly every state has had a private property rights bill introduced in its legislature. Numerous bills in Congress have also been introduced to protect private property interests from environmental regulation, typically endangered species and wetland protection laws. The bills fall into two general categories: assessment laws and compensation laws. Assessment laws will require an impact assessment on private property values as a part of issuing new regulations. Compensation laws will require cash payments to landowners whose land loses some fixed percentage of its market value as a result of environmental regulation. This paper will (1) review and summarize the key aspects of these two types of laws, and (2) describe, in non- technical terms, the analytical difficulties that will face those who would need to implement either law.

SESSION CW4

CONSTRUCTED WETLANDS: VEGETATION MANAGEMENT
Tommy E. Myers, Chair

IMPORTANCE OF OPEN WATER AREAS IN CONSTRUCTED WETLANDS AT SAN JACINTO CALIFORNIA

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Abstract

This paper relates the experiences of the first phase of monitoring at the Multipurpose Wetlands Research and Demonstration Facility in San Jacinto, California. It analyzes the results of water quality monitoring performed in eight research cells receiving secondary effluent, four of which are fully vegetated with bulrush and four of which have open water areas. Design and operating parameters for the research cells are given in Table 1.

PARAMETER	3 PHASE (MARSH POND-MARSH)	1 PHASE (UNIFORM MARSH)
Length (m)	13.7	13.7
Width (m)	68.6	68.6
Area (m^2)	939.5	939.5
Marsh Water Depth (m)	0.457	0.457
Pond Water Depth (m)	1.37	----
Total Volume (m^3)	649	469
Pond Volume (m^3)	309	----
Flow Rate (m^3/d)	46.4	33.3
Hydraulic Loading Rate ($m^3/m^2/d$)	0.049	0.035
Theoretical Hydraulic Retention Time (d)	11.9	12.0
N Loading Rate (kg N/ha/d)	9.08	6.49
NH_4^+-N Loading Rate (kg NH_4^+-N/ha/d)	5.73	4.09
BOD Loading Rate (kg BOD/ha/d)	2.40	1.71

The research cells were planted with California bulrush from on-site nursery cells during September 1992. Plant establishment and growth in the cells proceeded rapidly -- by July 1993, the bulrush shoots were too dense to count accurately. The first phase of water quality monitoring was conducted from May 5, 1992 to November 10, 1992. The results are presented in Table 2.

The total nitrogen removal efficiency differed dramatically in the two types of cells -- 58% removal in the three-phase vs. 11% removal in the one-phase cells. This was due primarily to the significant reduction in ammonium-N which occurred in the three-phase cells but not in the one-phase cells. There were no significant decreases in concentrations of biochemical oxygen demand (BOD) or (TSS) in either of the two types of cells. There was a slight increase in phosphorus in both types of cells.

The better performance of the cells with open water areas could be due to a combination of factors, particularly increased wind mixing and diffusion of oxygen and nitrate to the active sites for sequential nitrification/denitrification, algal assimilation of ammonia, and improved flow distribution. The completely vegetated cells were found to be less desirable in other ways, such as production of mosquito larvae and wildlife diversity. Interspersion of open water and marsh areas and a diverse selection of plants, perhaps including emergent, submerged, and floating aquatic species, is recommended in multipurpose constructed wetlands for maximum habitat, public enjoyment, and water quality benefits.

SEEDBANK COMPOSITION OF A CONSTRUCTED WETLAND

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Seedbank development on previously unvegetated sites can influence vegetation composition and dynamics. We removed sediment cores from coves, points, and straights, and from planted and unplanted regions of those locations along the shoreline of L-Lake, a created and planted cooling reservoir, to determine whether their seedbank composition differs. Sets of cores were taken from depths up to one meter, from the waterline, and from one meter above water, to determine the effects of hydrology on seedbank composition. Cores were split into unstratified samples that were kept at 5 C for 120 days before allowing germination in the greenhouse. As they emerged from cores, seedlings were identified or transplanted and left to flower for later identification. Results show that water depth is the primary influence on seedbank

TABLE 2
MEAN INLET AND OUTLET CONCENTRATIONS

PARAMETER	INLET	3 PHASE OUTLET	1 PHASE OUTLET
BOD(mg/l) (% change)	4.9	5.7 +17.22	5.1 +5.13
TOC (mg/l) (% change)	10.4	11.7 +12.39	11.1 +6.38
TSS (mg/l) (% change)	10	8.4 -16.00	4.6 -54.00
Turbidity (NTU) (% change)	4.1	10.2 +148.17	11.6 +183.30
Total Coliform (% change)	272,952	6,187 -97.73	45,430 -83.86
Fecal Coliform (% change)	305,200	4,212 -98.96	49,047 -83.93
Ammonium - N(mg/l) (% change)	11.7	5.67 -51.57	13.4 +14.55
Nitrite - N(mg/l) (% change)	1.93	0.616 -68.35	0.306 -84.14
Nitrate - N(mg/l) (% change)	0.772	0.764 -1.04	0.612 -20.73
TIN (mg/l) (% change)	14.261	5.622 -60.58	14.429 +1.18
TKN (mg/l) (% change)	16.143	6.7 -58.50	15.571 -3.54
TN (mg/l) (% change)	18.54	7.85 -57.68	16.48 -11.11
Total P (mg/l) (% change)	4.00	5.35 +33.75	4.92 +23.12
Ortho P (mg/l) (% change)	3.29	4.30 +30.90	5.34 +62.29

composition. Points, coves, and straights did not differ in species richness or number of germinable seeds. Planting did not significantly influence the seedbank and only 6% of species in the seedbank were planted.

ASSESSMENT OF PLANT PERFORMANCE IN CONSTRUCTED WETLAND MODULES: A NEW EXPERIMENTAL APPROACH

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The novel experimental approach combined trickling filter technology with hydroponic methods for cultivation of terrestrial and aquatic plants. A simple new tool was developed to study the application of constructed wetland technology in aquatic pollution control. The operation and application of this experimental tool is illustrated with reference to a specific study.

Modules were constructed from 35-gallon aquatic plant pots filled with pea gravel which were fitted with drainage ports to provide two water levels within the gravel (saturated and 50% saturated). Nutrient solutions from 400 liter reservoirs were pumped through 3 horticultural irrigation emitters, into each pot and returned to the reservoir. Plants of black willow (*Salix nigra*) were grown from stem cuttings and planted into the gravel. Nutrient solutions were designed to simulate a "typical" urban storm water and a "typical" secondary treated municipal wastewater. Complete plants were removed from the pots after 8 weeks of growth. Nutrient concentrations and water level in the gravel influenced biomass accumulation in black willow cuttings.

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SESSION MB5

MITIGATION AND MITIGATION BANKING: FUNCTIONS AND CREDITS

Dr. L. Jean O'Neil, Chair

WETLAND ASSESSMENT METHODS: APPLICATION TO MITIGATION BANKING

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As mitigation banks are established to generate credits to compensate for authorized losses of wetland functions, assessment methods for quantifying functions become increasingly important. Credits in the bank and debits from the impact site should be assessed using the same method so they can be expressed in the same units to facilitate trading, i,e,, setting compensation ratios. Unfortunately, two critical areas of mitigation banking - credit/debit evaluation and trade-off assessment - are currently limited by technical deficiencies.

The first difficulty (not attributed to any method) is often in defining which functions will be included as part of the bank's capital, and which will be evaluated during the debit determination. In addition to immense variability in wetlands, current assessment methods are varied in their capability to accurately assess individual functions, with the result that some functions may be emphasized simply because they can be evaluated. If functions are weighted in a similar fashion in trade-off decisions, then we may slight or lose a critical function just because a tool is lacking.

Banks present the need and opportunity to consider multiple functions; however, even the more advanced assessment methods are primarily limited to looking at individual functions. This may set up a situation in which two or more methods are used to determine credits and debits, which exacerbates the difficulties in trade-offs.

An inherent difficulty for any assessment is the size differential between a bank and most impact sites: one premise of a bank is to achieve economy of scale and develop "better" mitigation on a large area than on multiple small areas. As a bank increases in size, the probability increases that it will include non-wetland cover types which confound a credit evaluation for wetland functions. If our ability to directly quantify wetland functions is lacking, our skills in defining indirect functions (e.g., a wetland/terrestrial complex) are woeful. These problems are compounded when the bank credits are located "off-site" from the wetland sustaining the impact.

Experience with habitat evaluation over the last several years has shown both the great need to test and refine models for local conditions, and the great lack of such testing. The pace of decisions and the need for immediate solutions to wetland losses seldom allow the time and resources necessary to determine just how good our assessment methods are. In addition, standards of reference in the form of "control sites" are increasingly difficult to find.

The technical deficiencies that currently exist in wetland assessment methods place extra responsibilities on bank developers and users. Calculation of credits and debits is a critical component of a bank, with ecological and economic implications. Until methods and procedures improve, we recommend:

1. Flexibility in specification of methods to allow use of the best available;

2. The practice of adaptive management to take advantage of information and better methods as they are developed;

3. Greater attention to the risks to wetlands, e,g,, allow for time lags and uncertainty and make compensation ratios more conservative;

4. Documentation of methods used to calculate credits, including relevant decisions and assumptions; and

5. Additional data collection on wetland reference sites, interdependence of functions, and performance of assessment methods.

AN ALTERNATIVE METHODOLOGY FOR DETERMINING WETLAND FUNCTIONAL VALUES

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Certification of the Florida Power and Light Company Martin CG/CC Power Plant Project involved development of an alternative method for assuring "No net loss of wetland functional values". This Functional Value Methodology (FVM) involves familiar evaluation tools and is procedurally documentable. Elements of the US Fish and Wildlife Service HEP process and a decision making methodology are included. The FVM produces an index, which when multiplied by habitat acreage, results in Functional Value Units for the area of concern. The FVM steps are:

1. Definition and Weighting of Functional Value Parameters;

2. Definition of Subparameters;

3. Computation of Functional Value Parameter Indices;

4. Multiplication of a Functional Value Parameter Index by weight given a parameter; and

5. Multiplication of a Weighted Average Parameter Index to obtain Functional Value Units.

Several types of wetland Functional Value Parameters were identified for the Project, such as Endangered Species, Fish and Aquatic Systems, and Uniqueness. Functional Value Parameters are descriptive, but are insufficient to compare wetlands. Therefore, Subparameters were defined in quantitative terms as noted in the following example for the Fish and Aquatic Systems Parameter.

1. Extent

2. Water Availability

3. Canopy to Shrub Layer Percentage Cover

4. Rooted and Floating Aquatic Vegetation Percentage Cover

5. Probable Water Quality

Subparameters were selected which would provide relevant information about a particular Functional Value Parameter. Each Subparameter was graphically depicted as a function of a descriptive variable range against a Value Index scale of from 0 to 1 (Table 1). Figure 1 is an example from the Functional Value

TABLE 1 EXAMPLE OF THE FUNCTIONAL VALUE METHODOLOGY USING THE FPL MARTIN CG/CC PROJECT WETLAND E-10

FUNCTIONAL VALUE INDEX FOR THE PARAMETER FISH AND AQUATIC SYSTEMS

SUBPARAMETER	DATA POINT ON GRAPH
Extent (Acres with Maximum Depth of More Than One Foot)	1.0
Water Availability (Months with Water Present)	0.8
Canopy to Shrub Layer Percentage Cover	0.4
Rooted and Floating Aquatic Vegetation Percentage Cover	0.5
Probable Water Quality	0.5
TOTAL	3.2
FUNCTIONAL VALUE INDEX (AVERAGE)	0.64

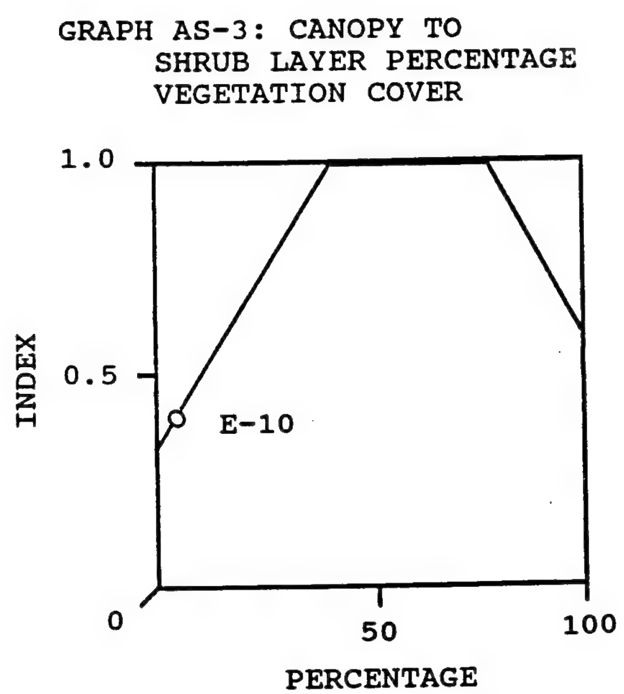
CALCULATION OF FUNCTIONAL VALUE UNIT

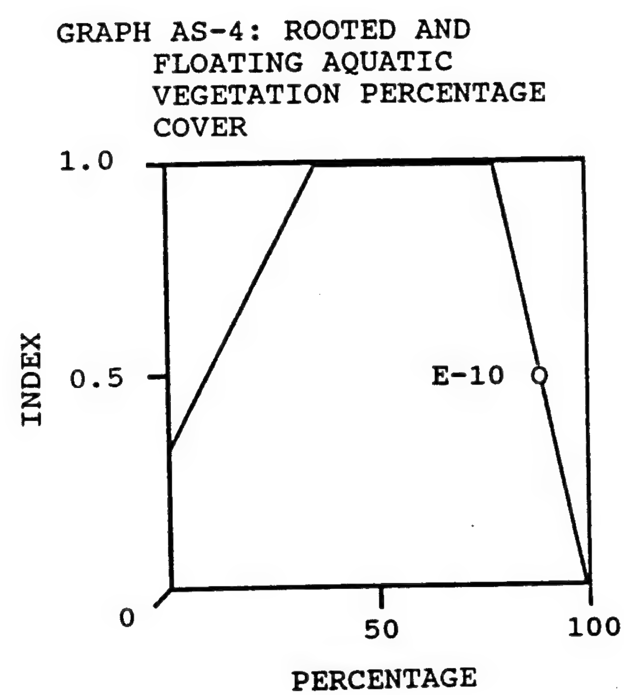
PARAMETER (IMPORTANCE VALUE)	FUNCTIONAL VALUE INDEX	WEIGHTED PARAMETER INDEX
Endangered Species (10)	0.33	3.29
Fish and Aquatic Systems (3)	**0.64**	**1.92**
Terrestrial Resources (8)	0.28	2.27
Uniqueness (6)	0.20	1.20
Aesthetics (2)	0.20	0.40
Water Quality (1)	0.70	0.70
Flood Control (1)	0.70	0.70
TOTAL		10.48

The Average Weighted Parameter Index is 10.48/7 = 1.5

Functional Value Units (FVU) for Wetland E-10 are calculated as its Average Weighted Parameter Index (1.5) multiplied by its acreage (16.9) which equals 25.4 FVU.

FIGURE 1 EXAMPLE SUBPARAMETER GRAPHS FOR THE PARAMETER FISH AND AQUATIC SYSTEMS





Parameter - Fish and Aquatic Systems, Subparameters were applied to each wetland by comparing actual field measurements or observations to each Subparameter graph. Results of all Subparameters within a Functional Value Parameter were averaged to arrive at a Functional Value Index.

Functional Value Parameters were weighted on a scale of 0 to 10 with 10 being the highest value. The weight assigned to each Functional Value Parameter was its Importance Factor. Each Functional Value Index for a wetland was multiplied by its Importance Factor to obtain a Weighted Parameter Index. The average of all the weighted indices represented an Average Weighted Parameter Index for a wetland. Functional Value Units (the basic units for comparing functional wetland value) were calculated for a wetland by multiplying the Average Weighted Parameter Index by the acreage of that wetland (Table 1).

APPLICATION OF A COMBINED APPROACH OF THE HYDROGEOMORPHIC METHOD AND LANDSCAPE ECOSYSTEM CLASSIFICATION ON THE NORTHEAST FLORIDA MITIGATION BANK

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A combined approach of Hydrogeomorphic Method (HGM) and Landscape Ecosystem Classification (LEC) provided a powerful tool for assessing function on the 386-acre Northeast Florida Mitigation Bank in Duvall County, Florida. HGM classifies wetlands by geomorphology and hydrology and assesses functions. LEC is a land classification approach that identifies vegetation patterns in relation to discriminating soil and landform variables and provides a greater level of refinement to the HGM classification. LEC has gained acceptance by the Forest Service and by state natural resource agencies in the eastern US for ecosystem management applications. The HGM reference wetlands were used to develop the LEC model for northeast Florida, The LEC model was used to predict the target vegetation community at each HGM sample point on the degraded mitigation site. Mapping of LEC units provided a spatial representation of the HGM assessment of potential functional gain across the mitigation site.

A QUANTIFIED METHOD FOR CALCULATING WETLAND MITIGATION BANK CREDITS USING WET VERSION 2,0

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One of the major obstacles facing a wetland mitigation bank sponsor is determining an acceptable method of calculating the wetland function and value credits available for exchange. This is especially true for large banks that may contain a diversity of habitat types, physical features, and hydrological functions within the bank itself or within its defined market area.

Using the Wetland Evaluation Technique, Version 2,0, as a

currently acceptable means of wetland assessment, a method for determining bank credits has been developed by prioritizing functions and values based on local/regional importance and by quantifying the probability ratings from a WET evaluation.

The Harris County Flood Control District has successfully proposed this methodology for use in its 1500-acre wetland mitigation bank located in northeastern Harris County, Texas. Our paper outlines this credit determination methodology and discusses the rationale behind its development.

THE COCOHATCHEE STRAND RESTORATION PROGRAM: A UNIQUE PROJECT-SPECIFIC MITIGATION BANK

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A wetland restoration and enhancement program was designed to function as an on-site mitigation bank and amenity for a 2,075-acre development project (the Pelican Marsh Community) in Naples, Florida. The isolated 133-acre wetland system (Cocohatchee Strand) consisted of predominantly Palustrine forested and scrub-shrub communities. Wetland functions had been adversely affected primarily by exotic plant infestations and by a severely degraded hydroperiod. Factors impacting Strand hydrology and hydroperiod included loss of historic sheetflow from contributing drainage basins, disruption of normal flow patterns within the Strand, and overdrainage. The restoration program was developed based upon an extensive investigation of existing site conditions. These efforts included water table monitoring, topographic surveys, wildlife surveys, vegetation mapping, stratigraphic characterization, specific capacity and constant-rate aquifer testing, and surface and ground water modeling using ICPR (Singhofen 1990) and MODFLOW (McDonald and Harbaugh 1988). The final program was designed in coordination with the developer. WCN Communities, following principles described by various authors (Hammer 1992; Kusler and Kentula 1990; Marble 1992).

The master plan for the resultant program is shown in Figure 1. This program called for conversion of exotic monocultures to native forested wetlands, marshes, and hammocks. Through clearing, grading, and re-planting, 17 forested areas and 6 marshes were re-established totaling 14.9 and 10.1 acres, respectively. Six areas totalling 41.5 acres had severe but scattered exotic infestations. Here, exotics were eradicated through a combination of herbicide applications and physical removal preserving desirable native vegetation. Large clearings left from removing exotics were re-planted similar to re- established forests.

The restoration program included innovative hydrologic restoration of the entire Strand, Hydrologic restoration primarily consisted of restoring historic drainage patterns and active pumping of surface waters into the Strand. Two large portions of the Strand severed by a canal and adjacent uplands were reconnected by constructing a land bridge over the canal (Figure 1) thereby restoring flow between the two Strand areas. A railroad grade within the Strand was largely removed thereby restoring normal sheetflow patterns. Two pumps were installed to divert surface water from the canal and exterior lakes into the Strand. Pumps were utilized since a design allowing gravity discharge of water into the Strand was not possible due to existing control elevations of adjacent developments and area groundwater elevations. Predictive MODFLOW and ICPR models were run prior to committing to the pumping scenario to ensure target hydroperiods were attainable. Pumping is conducted only during the wet season to supplement rainfall inputs. This pumping serves to increase the depth and duration of inundation mimicking the historic hydroperiod.

The mitigation bank formed by the restoration program was established using a sliding scale of "credits" linked to restoration success criteria. As well-defined success criteria are achieved over time the bank accrues more credits. A bank withdrawal system was created based on a matrix of quality ratings associated with wetlands which may be impacted by development. These quality ratings are based on the wetland type and its degree of degradation. The restoration program is now well underway and the banking and withdrawal system operative.

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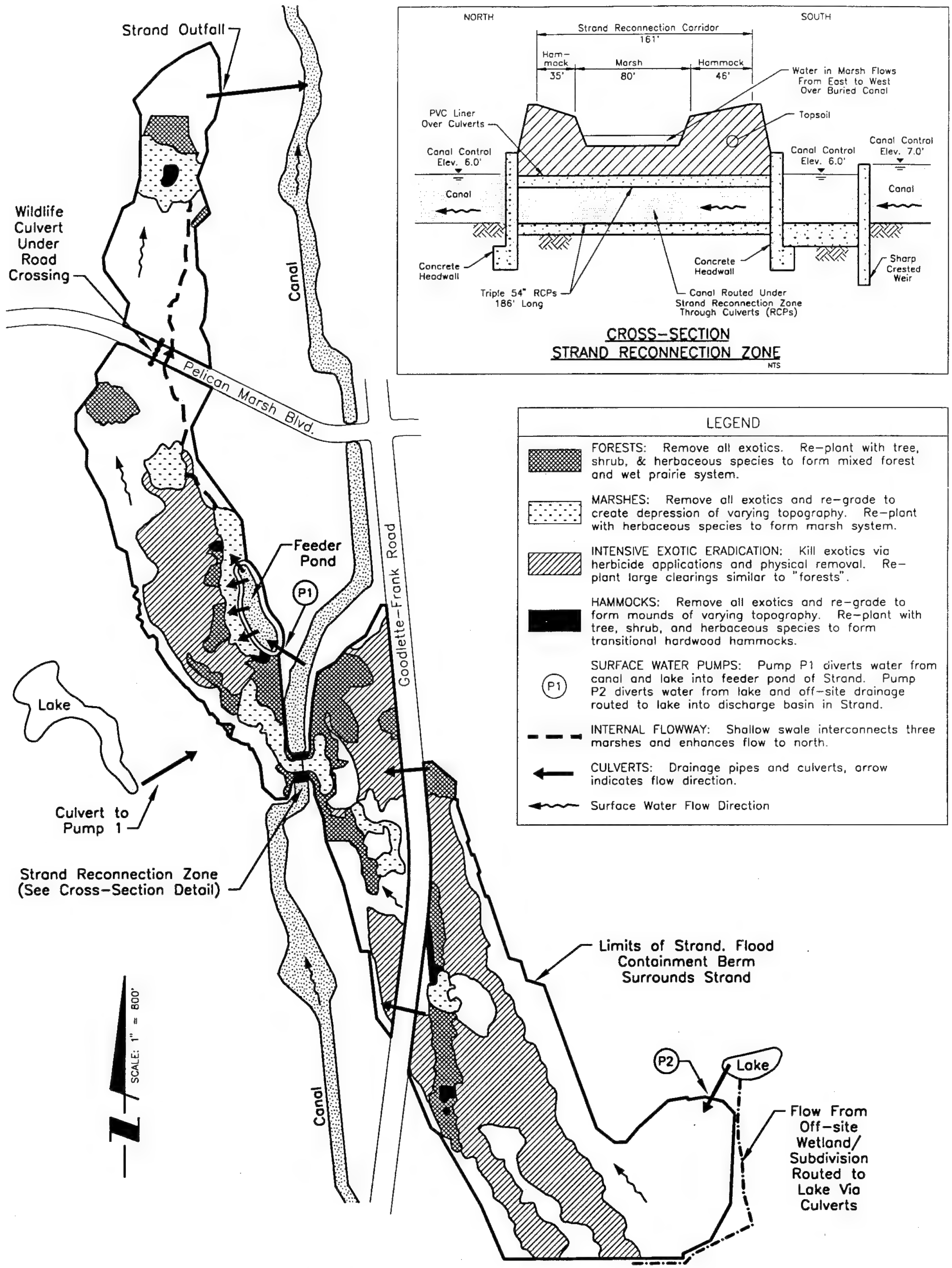

FIGURE 1. Cocohatchee Strand restoration program master plan.

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